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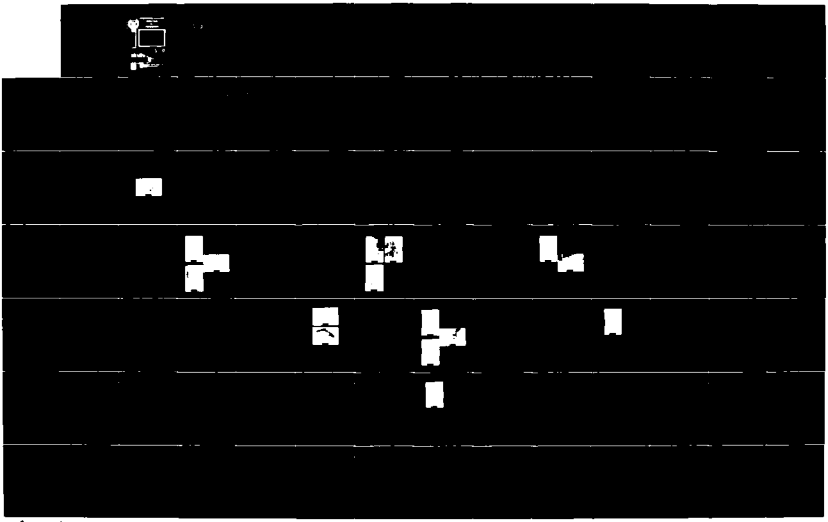

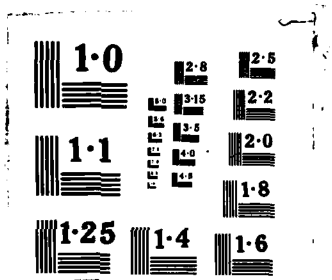
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AD-A167 548

UNDERWATER FACILITIES INSPECTIONS AND ASSESSMENTS AT

NAVAL SHIPYARD

CHARLESTON, SC

FPO-1-81 (8) MAY 1981

PERFORMED FOR:

OCEAN ENGINEERING AND CONSTRUCTION PROJECT OFFICE
CHESAPEAKE DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
WASHINGTON, D.C. 20374

UNDER:

CONTRACT N62477-80-C-0102
TASK 5

BY:

CHILDS ENGINEERING CORPORATION
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The objective of the underwater facility assessments conducted at the U.S. Naval Shipyard in Charleston, South Carolina is to provide a generalized structural condition report of designated facilities within the activity. These facilities are Piers DELTA, HOTEL and JULIET. Each facility was (Con't)

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inspected by a team of engineer/divers using a cobination of visual/tactile and ultrasonic techniques. Critical elements were photo-documented.

All three piers exhibited conditions which were consistent with their ages. The concrete piles in Pier DELTA were cracked and spalled in some areas, and a number of the steel piles in all three piers had undergone a severe amount of metal loss due to corrosion.

In Pier DELTA, approximately 50% of the concrete piles showed measurable amounts of deterioration, and all the steel H-piles had been reduced in capacity by corrosion. One steel H-pile exhibited some buckling in the flanges. However, the observed deterioration was not severe enough to cause the pier capacity to be downgraded. Since cracking aand psalling can hasten deterioration of concrete piles, it is recommended that repairs be filled with an epoxy grout. The steel H-pile with the buckled flanges should be repaired by extending its concrete jacket to elevation -9.0.'

Piers HOTEL and JULIET both exhibited a greater degree of deterioration that Pier DELTA. Although structural analysis calculations indicate that the pile foundations can still handle the imposed lods, piles supporting the 50-ton crane are approaching critical capacity due to the observed corrosion. Up to 50% if these piles in Pier HOTEL and up to 38% in Pier JULIET may be in this near-critical condition. These piles should be repaired as soon as possible by encasing them with 24" diameter concretejackets from the sound portion of the existing concrete jackets to elevation -10.0'

Beyond the deterioration due to corrosion, one pile in Pier JULIET was buckled, and 21 piles in Pier HOTEL were missing or buckled and/or fractured and displaced from the pile cap. The pier loadings in the areas of these damaged or missing piles should be reduced to dead load only until the piles are replaced.

All three piers should be reinspected in three years to document any further deterioration or damage and implement any necessary repairs. This report should be used as a baseline for these future inspections.

FOREWORD

The scope of the inspection at the Naval Shipyard in Charleston, South Carolina and the detail to which it was performed and reported was tailored specifically to the conditions at this facility. This report or the procedure associated with its formation is not intended to be a standard for inspections or reports covering other activities. Attempts are being made, however, toward establishing standards for procedures and formats for inspection and assessment reports. Through these standards, inspections performed by different persons, on many facilities and under a wide range of conditions can be effectively compared. It is expected that the inspections and assessments of the Naval Shipyard facilities, like previous operations mandated under the underwater portion of the Specialized Inspection Program, will contribute significantly toward achieving that objective.

It should be noted that the choice of the level of inspection and the procedural detail to be employed will be an engineering judgement made separately for each activity/facility to suit its unique situation and needs. Accordingly, the procedures used at the Naval Shipyard, rather than serve as a detailed model for inspections elsewhere, will provide guidance with general applicability to future inspections.

EXECUTIVE SUMMARY

The objective of the underwater facility assessments conducted at the U.S. Naval Shipyard in Charleston, South Carolina is to provide a generalized structural condition report of designated facilities within the activity. These facilities are Piers DELTA, HOTEL and JULIET. Each facility was inspected by a team of engineer/divers using a combination of visual/tactile and ultrasonic techniques. Critical elements were photo-documented.

All three piers exhibited conditions which were consistent with their ages. The concrete piles in Pier DELTA were cracked and spalled in some areas, and a number of the steel piles in all three piers had undergone a severe amount of metal loss due to corrosion.

In Pier DELTA, approximately 50% of the concrete piles showed measurable amounts of deterioration, and all the steel H-piles had been reduced in capacity by corrosion. One steel H-pile exhibited some buckling in the flanges. However, the observed deterioration was not severe enough to cause the pier capacity to be downgraded. Since cracking and spalling can hasten deterioration of concrete piles, it is recommended that repairs be performed on these piles as soon as possible. All cracked and spalled areas on the concrete piles should be filled with an epoxy grout. The steel H-pile with the buckled flanges should be repaired by extending its concrete jacket to elevation -9.0'.

Piers HOTEL and JULIET both exhibited a greater degree of deterioration than Pier DELTA. Although structural analysis calculations indicate that the pile foundations can still handle the imposed loads, piles supporting the 50-ton crane are approaching critical capacity due to the observed corrosion. Up to 50% of these piles in Pier HOTEL and up to 38% in Pier JULIET may be in this near-critical condition. These piles should be repaired as soon as possible by encasing them with 24" diameter concrete

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Beyond the deterioration due to corrosion, one pile in Pier JULIET was buckled, and 21 piles in Pier HOTEL were missing or buckled and/or fractured and displaced from the pile cap. The pier loadings in the areas of these damaged or missing piles should be reduced to dead load only until the piles are replaced.

All three piers should be reinspected in three years to document any further deterioration or damage and implement any necessary repairs. This report should be used as a baseline for these future inspections.

Refer to the following Executive Summary Table for an overview of each facility's construction, recommendations and cost estimates.

NAVAL SHIPYARD

CHARLESTON, SOUTH CAROLINA

EXECUTIVE SUMMARY TABLE

Facility	Year Built or Modified	No. of Vertical Bearing Piles	No. of Batter Piles	Facility Size	Structure
Pier DELTA	1915; Modified 1921, 1941 & 1968	1528	124	1130' long x 74' wide	16", 18" and 26" square precast, prestressed concrete piles. Also concrete-encased (to El. -3.0') steel H-piles (HP12x53).
Pier HOTEL	1942; Repaired 1967	1248	126	865' long x 80' wide	Concrete-encased (to El. -3.0'), steel H-piles (HP12x53).
Pier JULIET	1942; Repaired 1971	1248	126	865' long x 80' wide	Concrete-encased (to El. -3.0') steel H-piles (HP12x53).

NAVAL SHIPYARD

CHARLESTON, SOUTH CAROLINA

EXECUTIVE SUMMARY TABLE

). of atter iles	Facility Size	Structure	Recommendations	Est. Cost of Recommendations
124	1130' long x 74' wide	16", 18" and 26" square precast, pre-stressed concrete piles. Also con-crete-encased (to El. -3.0') steel H-piles (HP12x53).	1) Repair spalled and cracked concrete piles by patching with an epoxy grout.	$40,000-$70,000
			2) Repair steel H-pile with buckled flanges by extending concrete jacket down to El. -9.0'.	$ 2,500
126	865' long x 80' wide	Concrete-encased (to El. -3.0'), steel H-piles (HP12x53).	1) Restrict loading on pier in area of missing or buck-led piles (see Section 4.2.4).	
			2) Replace buckled or missing piles with new pile posts.	$72,000
			3) Piles supporting 50-ton crane which are approaching critical capacity should have concrete jackets extended to El.-10.0'.	$95,000
126	865' long x 80' wide	Concrete-encased (to El. -3.0') steel H-piles (HP12x53).	1) Restrict loading on pier in area of buckled pile (see Section 4.3.4).	
			2) Replace buckled pile with new pile post.	$ 3,400
			3) Piles supporting 50-ton crane which are approaching critical capacity should have concrete jackets extended to El.-10.0'.	$72,000

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This report is a product of the Underwater Inspection Program conducted by the Ocean Engineering and Construction Project Office (FPO-1), Chesapeake Division, Naval Facilities Engineering Command (NAVFACENGCOM) under NAVFAC's Specialized Inspection Program.

This program sponsors task-oriented engineering services for the inspection, analysis and design and monitoring of repairs for the submerged portions of selected Naval Waterfront Facilities. All services required to produce this report were provided by Childs Engineering Corporation of Medfield, Massachusetts under Tasks No. 4 and 5 of Contract No. N62477-80-C-0102.

The efforts expended and costs required to perform these underwater facility inspections vary greatly with the size, age, kind and construction type of the facilities involved. Other factors peculiar to a particular facility or activity also have an important effect on inspection time and costs. These factors include:

*Type and quantity of biofouling to be cleaned for different levels of scrutiny, both visual and with instruments;

*Tidal range - area exposed at low tide for boat inspection;

*Time and type of last inspection;

*Local environmental factors - salinity, pollution level, temperature, etc., affecting rates of corrosion and marine life;

*Function of the facility and the level of activity associated with that function.

1.1 TASK DESCRIPTION

The scope of work under Task No. 4 of the program required the inspection of the underwater portion of designated piers located at the Naval Shipyard in the Charleston Naval Complex

in South Carolina. The quality of inspection had to be sufficient to provide an adequate general structural assessment of the facilities and to identify areas of sufficient damage and/or deterioration to warrant immediate repair or a future, more detailed investigation.

This report, which provides a generalized structural condition assessment of the designated piers at the Naval Shipyard, is covered under Task No. 5 of Contract No. N62477-80-C-0102.

1.2 REPORT CONTENT

The report contains a description of inspection procedures, the results of the inspection and analysis of the findings, accompanied by pertinent drawings and photographs. Specifically, the inspection results include a description of the location, construction and function of each facility examined within the Naval Shipyard, its observed condition and a structural assessment of that condition. Recommendations for each facility, including cost estimates (based on present local prices) for any repair work, are also included. Structural assessment calculations and cost estimate breakdowns can be found in the Appendix. Also, as supplementary information, a brief description of the Naval Shipyard is provided to define its location, mission, history, existing facilities, climate and hydrographic and topographic features.

This section provides a general description of the Naval Shipyard, which is one of eight commands within the Charleston Naval Complex in South Carolina. The description includes brief discussions of the Naval Shipyard's location, mission, history, existing facilities, climate, topography and hydrology. This information provides a more overall view of the activity and a perspective to accurately assess the structural conditions of the facilities inspected.

2.1 LOCATION OF ACTIVITY

The Naval Shipyard is located on the Atlantic seaboard, approximately 12 miles north of the city of Charleston, South Carolina, in Charleston County. It is contained within the Naval Base South area of the Naval Complex and covers 1,910 acres. The Shipyard lies on the west bank of the Cooper River, beginning approximately 12 miles upriver from the mouth of Charleston Harbor and continuing upstream for about 2 miles (see Figure 1).

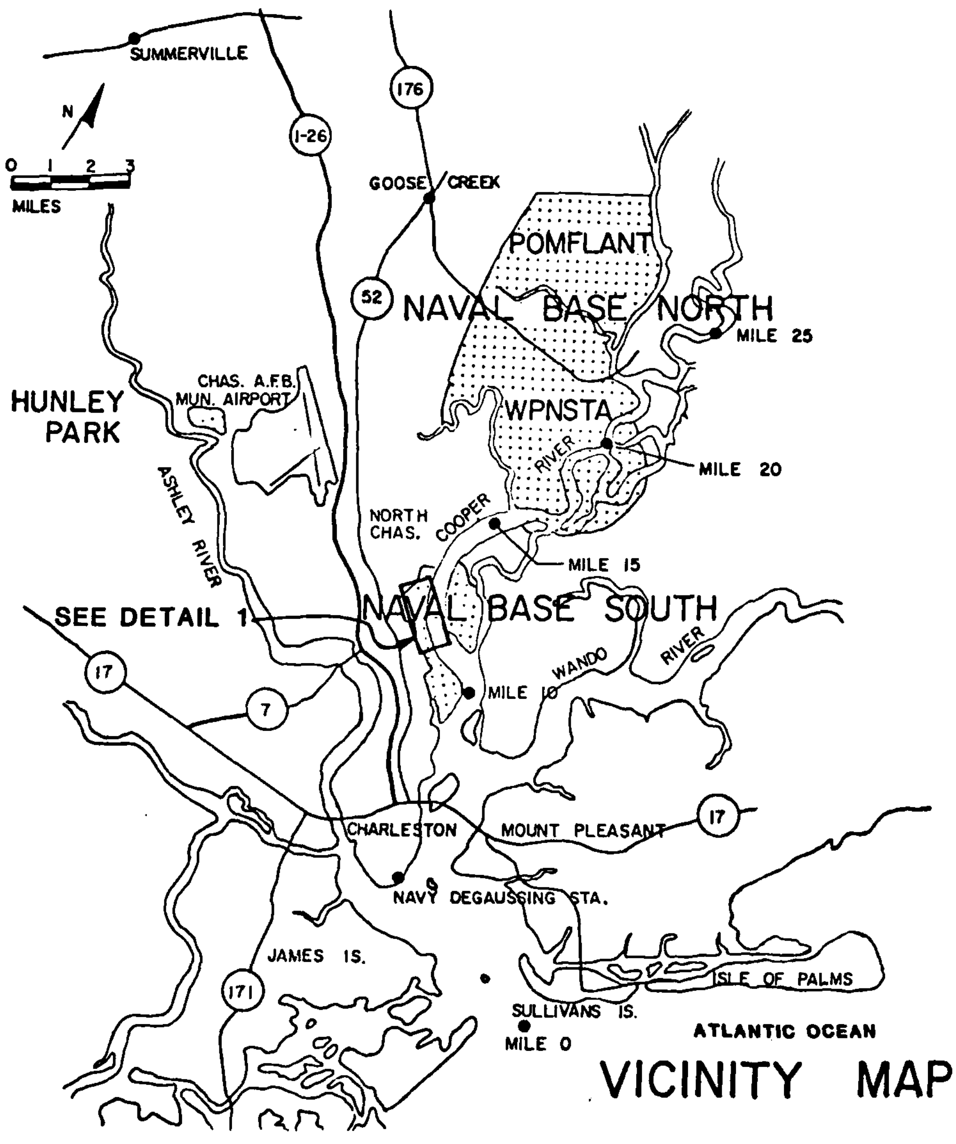
2.2 MISSION OF ACTIVITY

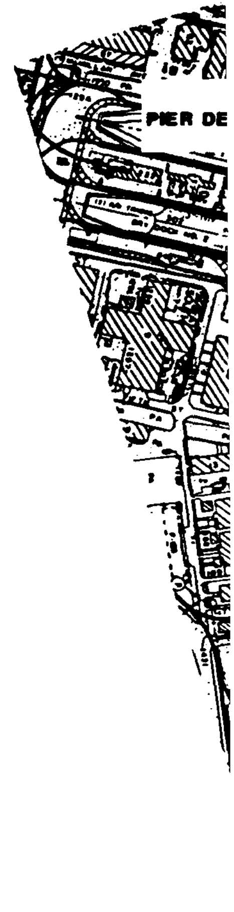
"The official mission of the Charleston Naval Shipyard is: To provide logistic support for assigned ships and service craft; to perform authorized work in conversion, overhaul, repair, alteration, dry-docking, and outfitting of ships and craft as assigned; to perform manufacturing research, development, and test work as assigned; and to provide services and material to other activities and units, as directed by competent authority. In general, the Shipyard is almost exclusively an overhaul and repair facility." [1]

2.3 HISTORY OF ACTIVITY

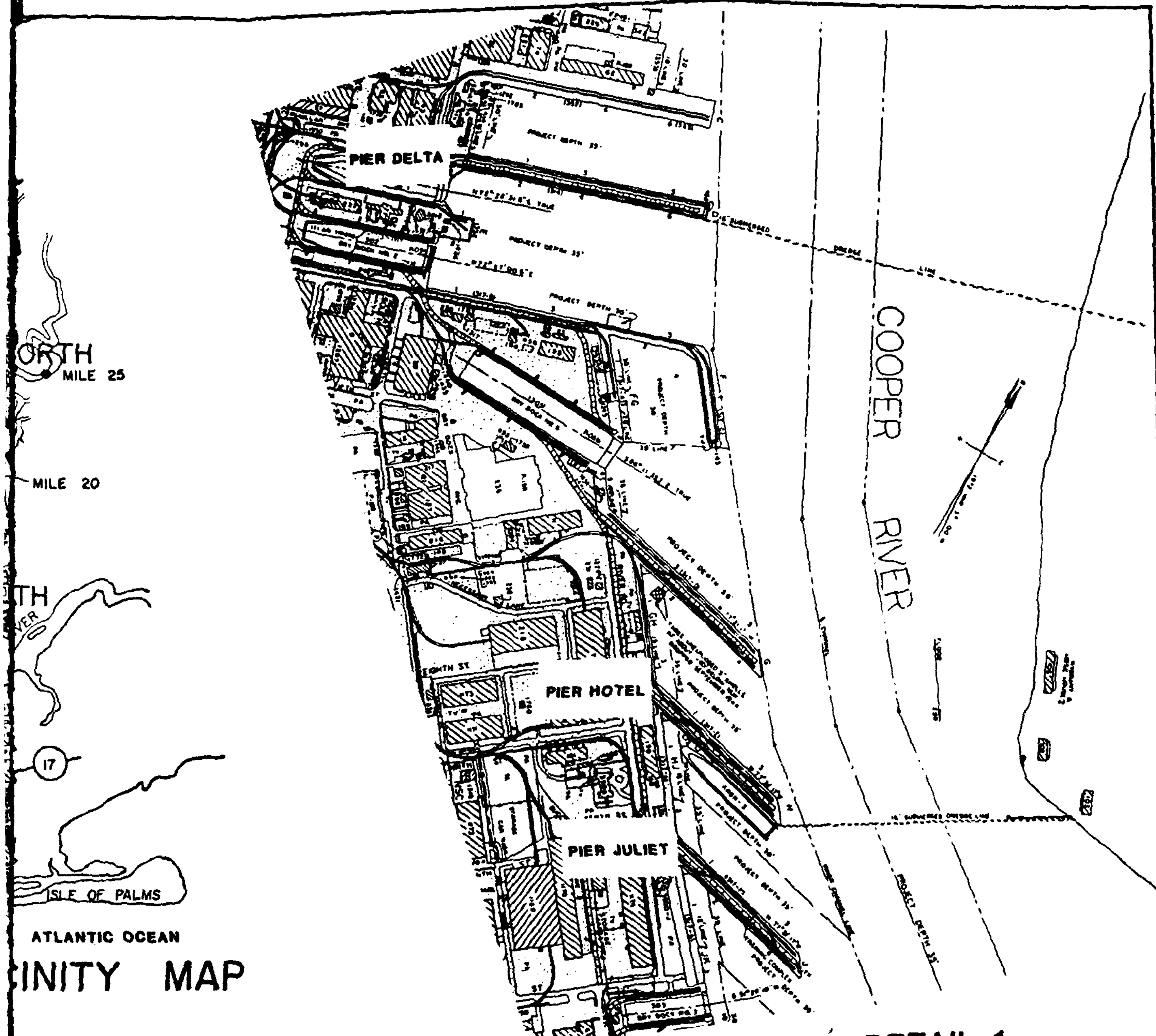
"Shipyard employment peaked at some 5,000 workers during World War I, but dropped to 500 during the postwar 1920s. In 1933, Charleston was designated as a new construction yard.

High waterfront employment and activity came during World War II when the shipyard grew to meet its ship repair, conversion and new construction responsibilities. During this





NOTE: Vicinity Map Taken From MASTER PLAN, Charleston Naval Complex, Southern Division, Naval Facilities Engineering Command.
Detail 1 Taken From P.W. Dwg. No. H606-254.



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DETAIL 1

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GRAPHIC SCALE	Childs Engineering Corporation Box 333 Medfield, MA	CHESAPEAKE DIVISION NAVAL FACILITIES ENGINEERING COMMAND WASHINGTON, D.C.	
N/A		NAVAL SHIPYARD CHARLESTON, SC LOCATION PLAN	FIG NO. 1

period some 26,000 employees sent over 200 ships - primarily destroyer and amphibious ship classes - into the conflict.

When peace returned, production decreased, but technological demands on the shipyard continued to increase. New ship construction was discontinued, but ships with more complex post World War II components, were assigned for conversion, alteration, and repair.

In 1948, Charleston was designated as a submarine repair and overhaul center. During the mid 1950s, conversion work took an upswing with the assignment of a number of maritime ship hulls for modification to Radar Station Ships and Ocean Survey Ships. Charleston also became the East Coast naval shipyard primarily repsonsible for support of mine warfare ships.

In 1961, the shipyard was given the responsibility of design support for the Polaris submarines that were then starting operational patrols. Submarines, plus more of the newest naval ships of other classes, are now being assigned to Charleston for operational home porting and for shipyard overhaul support.

At present, engineering and industrial support reponsibilities continue to increase. Shops have been expanded and equipped to meet the demands of these new ships. Facilities at the Shipyard include a drydock specifically designed for servicing FBM submarines and other nuclear-powered ships."[2]

2.4 EXISTING FACILITIES

"Naval Shipyard has five dry docks and one floating dry dock. The drydocks designated THREE and FOUR are obsolete due to their physical condition and the depth of water over the entrance sill. They are exclusively used for dry storage of miscellaneous Navy barges and floating equipment. Drydocks ONE, TWO and FIVE can accommodate any of the ships in the Shipyard's projected workload and Drydock FIVE has the additional ability for multiple dockings. The floating drydock is an ARDM and can accommodate only submarines and the smaller destroyer and destroyer escort classes.

Naval Shipyard has six piers with sixteen berths. The maximum number of useable berths is twelve or 6800 linear feet of berthing. Fourteen portal cranes, with capacities ranging from fifteen to fifty tons, along with eight locomotive cranes, and three floating cranes are available for use on the waterfront."[3]

2.5 CLIMATE

"In general the climate of the area is temperate, modified considerably by the nearness of the ocean. Monthly wind speeds average 9 mph with wind directions varying with the season. The area is subject to occasional hurricanes between July and September.

The area experiences no dry seasons although nearly 41% of the 49 inches of average annual precipitation occurs during the summer months. Thunderstorms are most frequent during the summer."[4]

Mean monthly precipitation ranges from a low of 2 inches to a high of 7.5 inches. Relative humidity ranges from an annual low of 57% to a high of 87%. Average annual sunshine is about 64% of maximum.

The annual temperature ranges from 55° to 75° F. with a mean of 62° F. Summer temperatures (June to August) range from 70° to 90° F. with an average of 80° F., while winter temperatures (December to January) range from 37° to 57° F. with an average of 47° F.

2.6 TOPOGRAPHY AND HYDROLOGY

"The Charleston Naval Complex is located in an area of very level topography. The maximum elevation of this area is approximately 35 feet above mean sea level. This level topography along with the rainy, humid climate of the region, produces many slow draining areas. Naval Base South tends to be swampy with little relief; on the other hand, Naval Base North has an abundance of fresh water ponds and extensive forests."[5] Ground water is found from 2 to 18 feet beneath the surface.

"The basic flood used for Navy planning is the 100 Year Flood. This identifies an elevation that rising water is expected to reach once in every 100 years. The 100 year flood plain for the Charleston area is 10 feet above mean sea level. All buildings containing materials dangerous to the public, residential buildings, and buildings needing a high degree of protection must be sited above the 100 year flood plain."[6]

Almost all the land within Naval Base South lies below the 100 year flood plain, making it nearly impossible to comply with this siting restriction. However, Naval Base North contains considerable usable area above the 100 year flood plain.

Although the Naval Shipyard is located between 12 and 14 miles upstream from the mouth of Charleston Harbor, it is tidally influenced and is marine in character. Tidal ranges for the Naval Shipyard are as follows:

	Feet
MEAN LOW WATER	0.0
MEAN TIDE LEVEL	2.6
MEAN TIDE RANGE	5.2
SPRING TIDE RANGE	6.1

The Naval Shipyard requires regular dredging to remove the considerable amount of silt deposited by the river. The river channel is maintained at a depth of 35 feet below mean low water.

Between March 16 and April 14, 1981, a team of one engineer and two technicians, all certified SCUBA divers, performed an on-site underwater inspection of selected piers at the Naval Shipyard, Charleston, South Carolina. The level of inspection to be performed, the type of structure being inspected, actual on-site conditions and past experience, combined with a thorough knowledge of engineering theory, dictated the inspection procedures that were followed.

3.1 LEVEL OF INSPECTION

The inspection techniques used had to be sufficient to yield information necessary to make a general condition assessment of the supporting structure of each facility, identify any areas that were mechanically damaged or in advanced states of deterioration, and formulate repair and maintenance recommendations and cost estimates. In general, this meant utilizing visual/tactile inspection techniques, accompanied by occasional external measurements employing such instruments as a scale, calipers or ultrasonic steel thickness gauge, where appropriate. Photographic documentation of typical as well as notable or unusual conditions was also obtained.

3.2 INSPECTION PROCEDURE

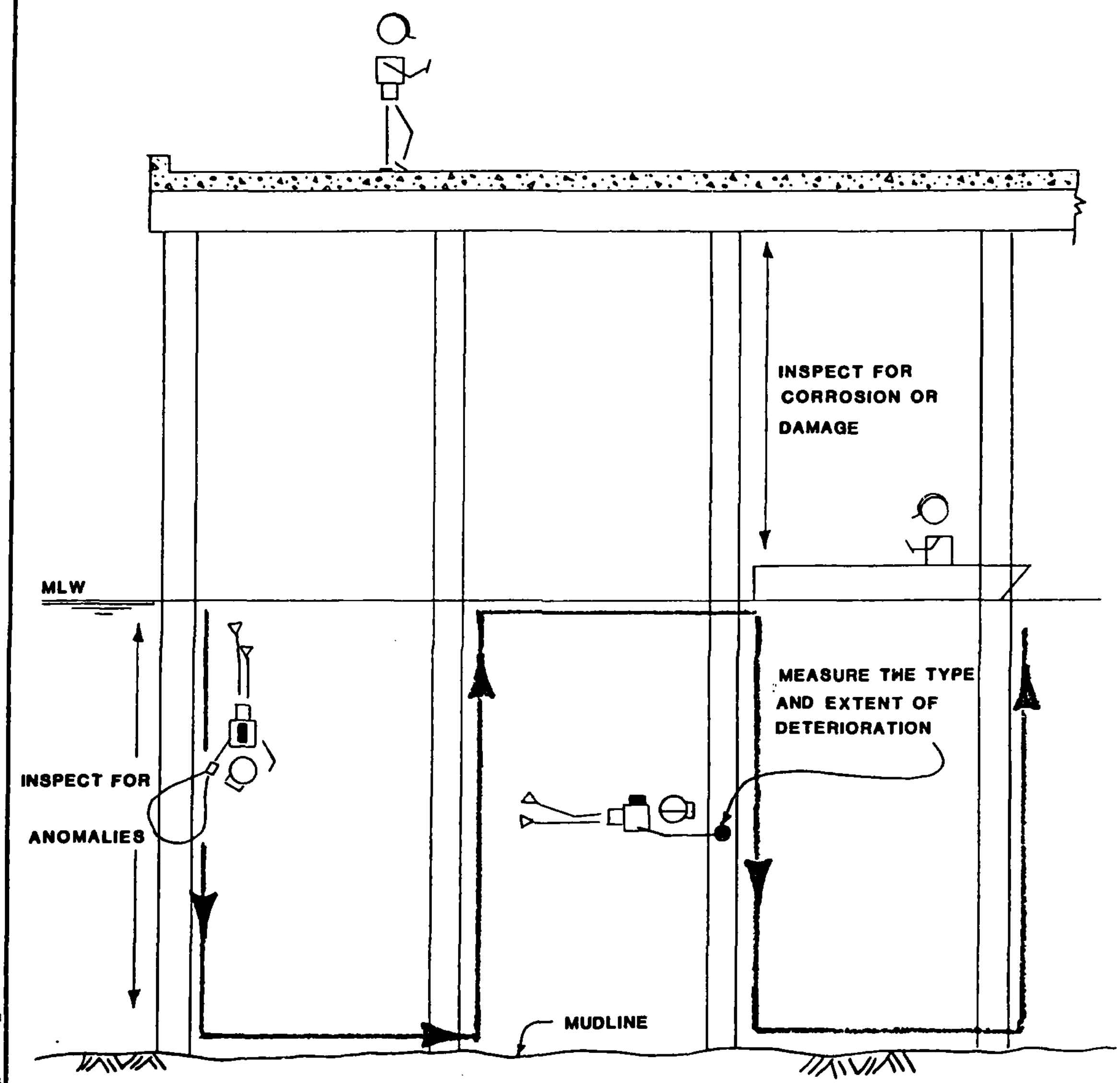
The scope of work for Task No. 4 of Contract No. N62477-80-C-0102 required that three stationary piers at the Naval Shipyard be inspected from the splash zone (practically speaking, the pile cap) to the mudline for general conditions and any gross structural damage or deterioration. The fender and utility systems were beyond the scope of this inspection.

A dive team consisting of two divers and one tender/ notekeeper performed the on-site inspection. Past experience has proven this arrangement to be efficient as well as safe. Depending on the layout of the piles, divers would either inspect alternate bents or each take a portion of a bent. A minimum of 20% of the piles of each facility were closely inspected from the pile cap to mudline. The remainder of the piles were given a more cursory "swim-by" inspection, normally at mean low water as much of the damage or deterioration was seen in this area. Usually, every fifth bent was inspected closely in a manner similar to that depicted in Figure 2. Soundings were taken at intervals around the perimeter of each facility.

Often it was necessary to remove marine growth and/or corrosion from some surface areas of selected piles for an adequate structural assessment. Small patches were frequently cleared during a close inspection. If the piles were steel, ultrasonic thickness readings were taken in the cleaned area.

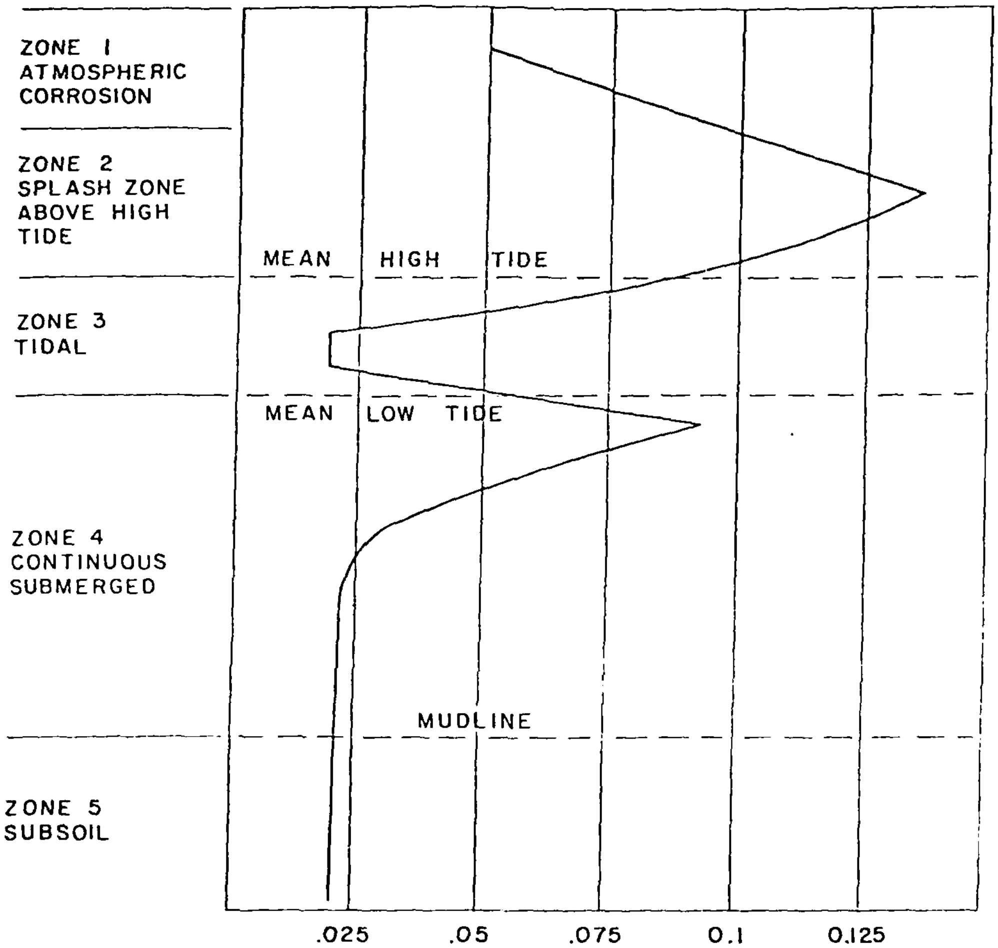
For facilities with reinforced concrete piles, inspection involved the noting of any cracking, spalling or rusting. Piles were hit with a hammer to gauge the soundness of the concrete and any softness that might be present.

For facilities with exposed steel piles, corrosion of the metal was an important concern. Based on classical corrosion curves, as shown in Figure 3, areas of maximum corrosion usually occur at or around mean low water (MLW), within 2 feet of the mudline, in the splash zone and in areas where a differential oxygen concentration cell is set up. This latter case can occur at the interface or boundary areas



TYPICAL DIVER INSPECTION PATH

GRAPHIC SCALE	Childs Engineering Corporation Box 333 Medfield, MA	CHESAPEAKE DIVISION NAVAL FACILITIES ENGINEERING COMMAND WASHINGTON, D.C.	
N/A		NAVAL SHIPYARD CHARLESTON, SC	FIG NO. 2



RELATIVE LOSS IN METAL THICKNESS

CORROSION PROFILE OF STEEL PILING – FIVE YEARS EXPOSURE IN SEAWATER

FROM: S. C. FYRE, "THE PROTECTION OF PILING" IN DESIGN AND INSTALLATION OF PILE FOUNDATIONS AND CELLULAR STRUCTURES, ED., HSAI-YOUNG FANG AND THOMAS D. DISMUKE (PENNSYLVANIA: ENVO PUBLISHING CO., INC 1970) PP 191–207.

GRAPHIC SCALE	Childs Engineering Corporation Box 333 Medfield, MA	CHESAPEAKE DIVISION NAVAL FACILITIES ENGINEERING COMMAND WASHINGTON D.C.	
N/A		NAVAL SHIPYARD CHARLESTON, SC — CORROSION PROFILE FOR STEEL PILES	FIG NO 3

between concrete and steel. As a result, the steel adjacent to the concrete is sacrificed to protect the steel under the concrete.

To document the corrosive activity, corrosion profiles were taken on selected piles. Small areas of the pile were cleaned to bare metal at selected elevations and metal thickness was measured with an ultrasonic thickness gauge and/or calipers. The number of readings taken per pile and the number of piles measured per facility were based on profiles previously obtained and on experience.

It should be noted that during our investigation no destructive testing was performed. The conditions noted reflect direct observation or measurement of structural components which were accessible. Information which may infer knowledge of conditions of hidden components are based on government-furnished documents, our knowledge of structures in similar environments and/or generally accepted engineering theories.

3.3 INSPECTION EQUIPMENT

Equipment used for the inspection included a Krautkramer D-meter ultrasonic steel thickness gauge with DMR probe and 75 feet of cable, a Minolta SRT 200 camera with 28mm and 50mm lenses and strobe, a Nikonos III underwater camera with Nikon closeup lens and 7" x 9" stainless steel framer, water box (for use in low visibility conditions) and strobe, dive lights, 100-foot sounding tape, 50-foot cloth tape, 6-foot folding rule, calipers, chipping hammers and dive knives.

Choice of equipment was made as a result of past experience. Most of the equipment is straightforward, easy to handle, carry and use, and has proven reliable under hard use.

Ultrasonic steel thickness gauging is preferred over other techniques (such as drilling test holes) since it is non-destructive, easy to handle, fast and reasonably accurate.

Within this section of the report, each facility inspected at the Naval Shipyard is referenced separately. The discussion of each facility is presented in four parts: 1) a description of the construction and function of the structure, which is derived both from the on-site inspection and from the referenced government-furnished drawings; 2) an enumeration of general and specific conditions observed during the on-site inspection; 3) a qualitative assessment of the structural condition of the facility based on the inspection data; and 4) recommendations for actions to be taken to insure long-term, cost-effective maintenance and utilization of the facility. Detailed breakdowns of cost estimates are included in the Appendix.

Marine growth profiles were noted for each facility. These profiles were similar for all the facilities at the Naval Shipyard. In general, oysters, mussels and barnacles, along with a mat of hairlike growth covered both steel and concrete piles from mean low water to mudline (see Photo #1). The growth often thinned out within 6" - 12" of mudline, probably due to scouring. Oysters and the hairlike mat extended out 4" - 5" in places, but averaged in thickness from 1" - 3". Growth thinned out above mean low water to sporadic clumps of small oysters and mussels and a scattering of barnacles, all of which ended in the splash zone. Figure 4 illustrates the general growth pattern.

On the steel piles, deposits of black corrosion by-product with gas pockets trapped beneath were common. This corrosion buildup was not heavy, usually less than 1/4". An example of this type of corrosion is illustrated in Figure 5.

PHOTO #1: Example of Marine Growth Observed at the Naval Shipyard Around Mean Low Water (Pier JULIET)

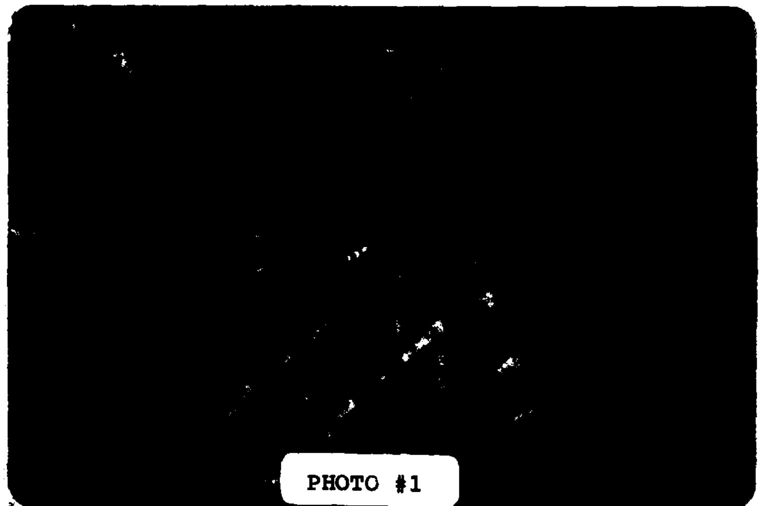
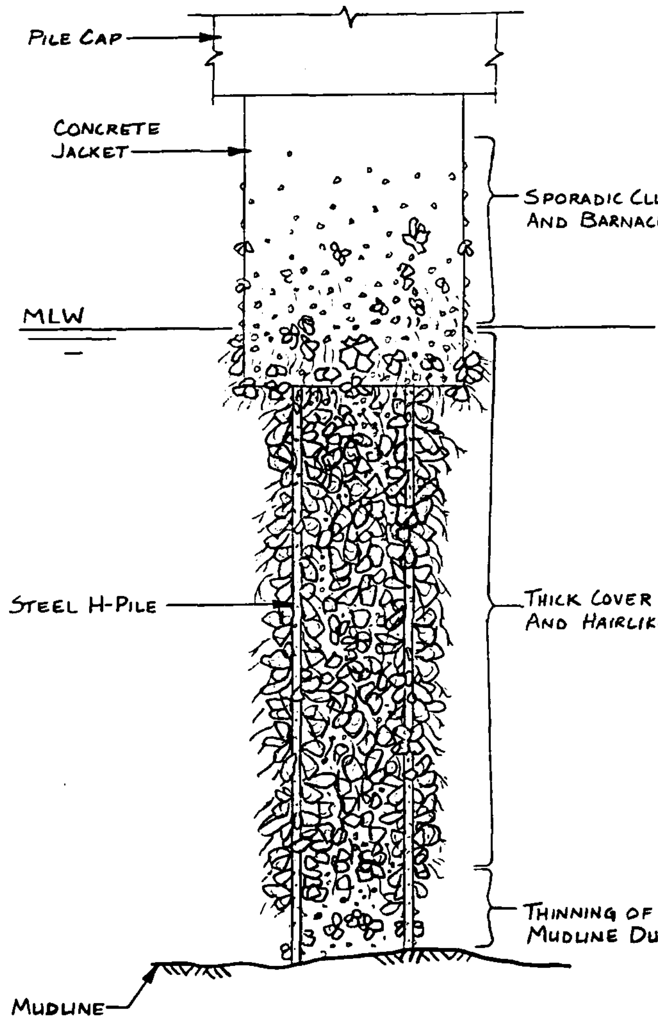
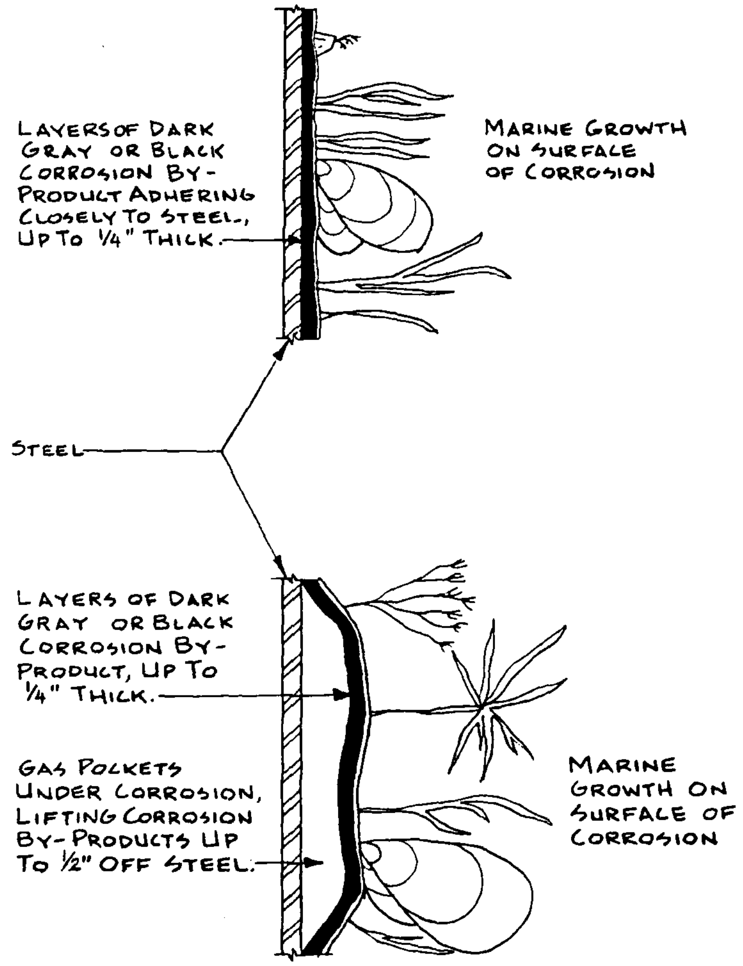


PHOTO #1



GRAPHIC SCALE	Childs Engineering Corporation	CHESAPEAKE DIVISION NAVAL FACILITIES ENGINEERING COMMAND WASHINGTON, D.C.	
NOT TO SCALE		NAVAL SHIPYARD CHARLESTON, SC — MARINE GROWTH PROFILE	FIG. NO. 4



GRAPHIC SCALE	Childs Engineering Corporation	CHESAPEAKE DIVISION NAVAL FACILITIES ENGINEERING COMMAND WASHINGTON, D.C.	
N/A		NAVAL SHIPYARD CHARLESTON, SC TYPICAL CORROSION BUILDUP	FIG NO 5

The phrase "cosmetic spalling" is frequently used in this section. It is used to indicate surface spalling of concrete that does not affect the structural integrity of the structure.

4.1 PIER DELTA

4.1.1 Description

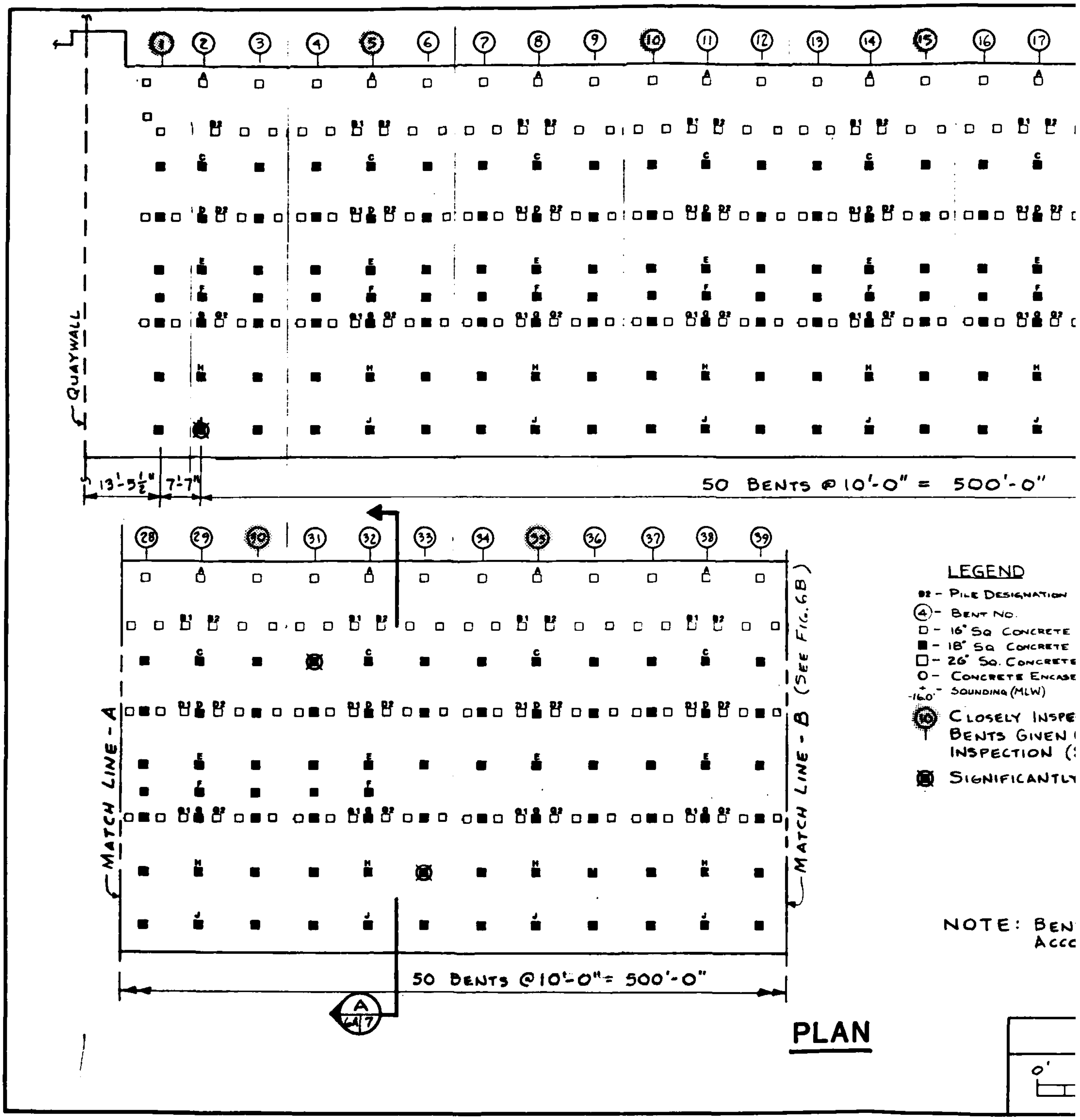
Pier DELTA is the northernmost facility inspected at the Naval Shipyard. Located on the west bank of the Cooper River, it was functioning as a berthing area for a guided missile destroyer (DDG), a caisson for a basin dock and an assortment of barges during the inspection period. The pier is provided with highway and railroad access and a portal crane.

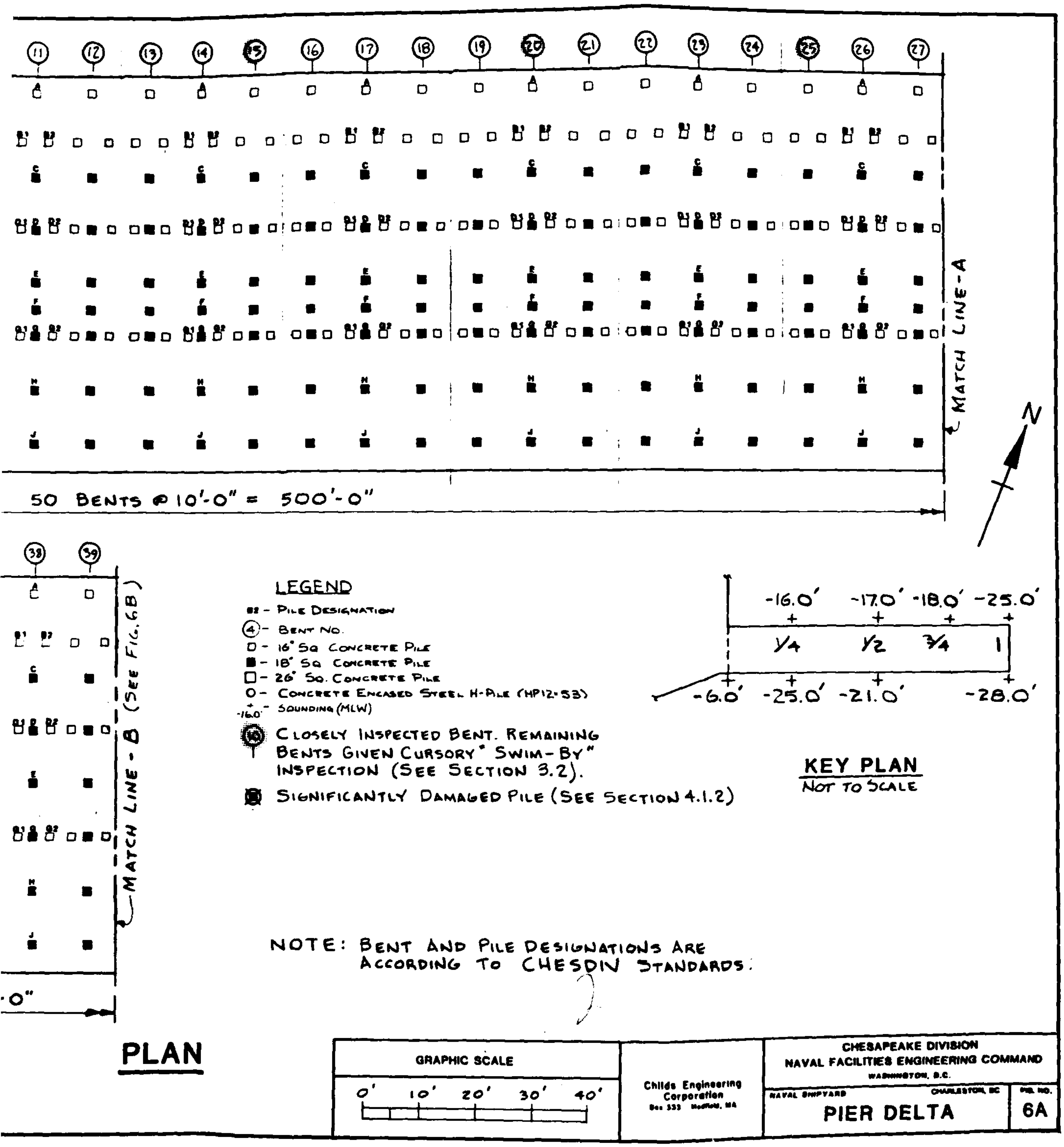
Pier DELTA has been rebuilt and modified several times, with the original pier appearing around 1915. A second increment was added in 1921 and a third in 1941. In 1968, the pier was reconstructed and widened into the 1130' long x 74' wide structure which is presently in use (see Figures 6 and 7). The 82 bents of the pier are comprised of a variety of pile types: 16", 18" and 26" square precast, reinforced concrete piles and steel HP12x53 piles, with 28" diameter concrete jackets running from the pile cap to -3.0' below mean low water (MLW). The piles added in 1968 are 16" square concrete piles which are designed for a capacity of 55 tons. The design live load for the deck added in 1968, in areas not occupied by cranes, is 600 PSF.

In all, 1528 vertical and 124 batter piles support the reinforced concrete decking, railroad and crane rail tracks.

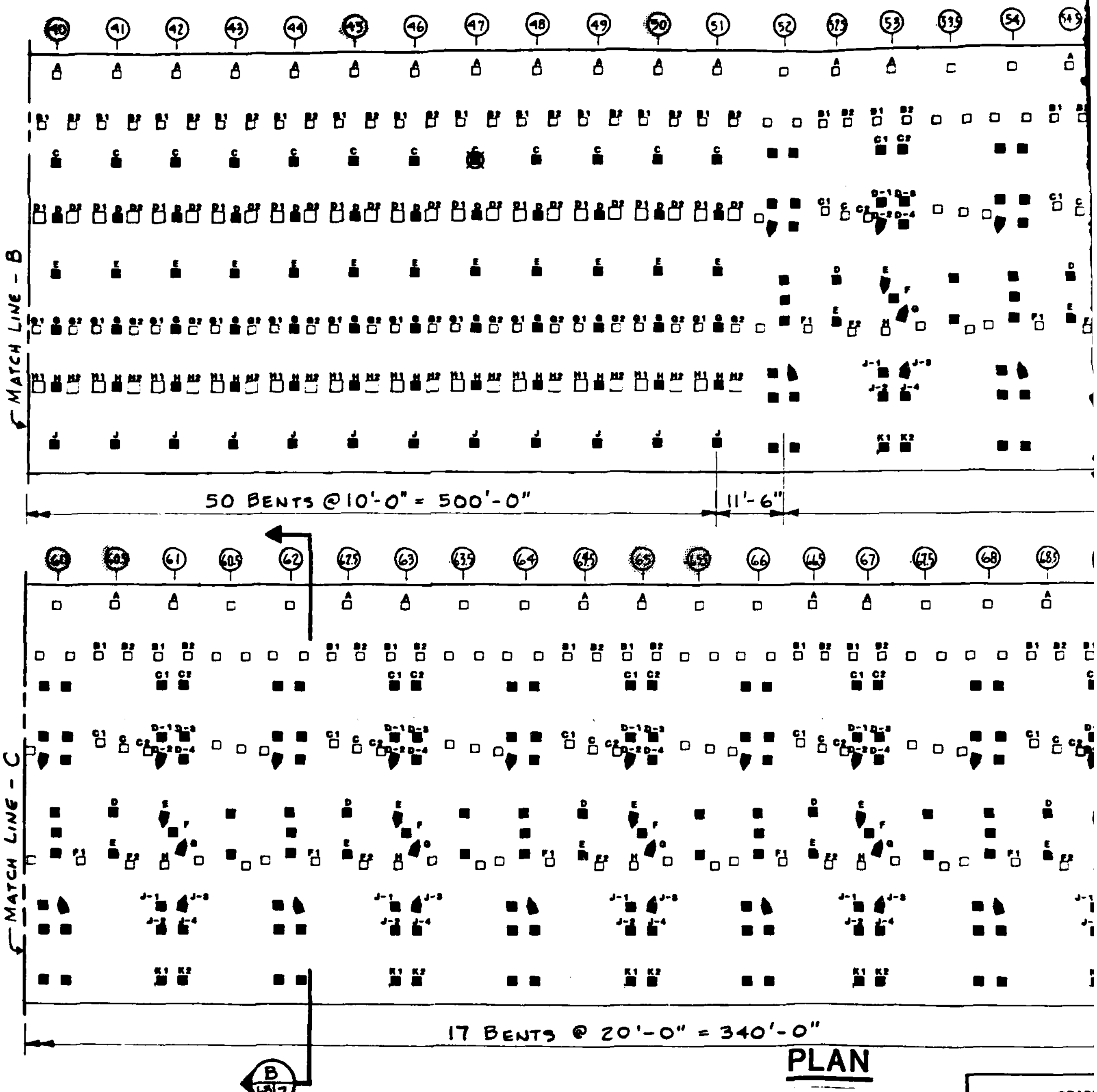
References: Southeast Division, Naval Facilities Engineering Command
"Widening Pier 314"
NAVFAC Dwg. #1277274, #1277275, #1277279, #1277280, #1277282 and #1277284

34


QUAYWALL
13'-5 1/2"
7'-7"
50 BENTS @ 10'-0" = 500'-0"
MATCH LINE - A
MATCH LINE - B (SEE FIG. 6B)
50 BENTS @10'-0" = 500'-0"
A
6/7
LEGEND
B2 - PILE DESIGNATION
4 - BENT NO.
16" SQ CONCRETE
18" SQ CONCRETE
26" SQ. CONCRETE
CONCRETE ENCASE
-16.0' SOUNDING (MLW)
CLOSELY INSPE
BENTS GIVEN
INSPECTION (
SIGNIFICANTLY
NOTE: BEN
ACC
PLAN

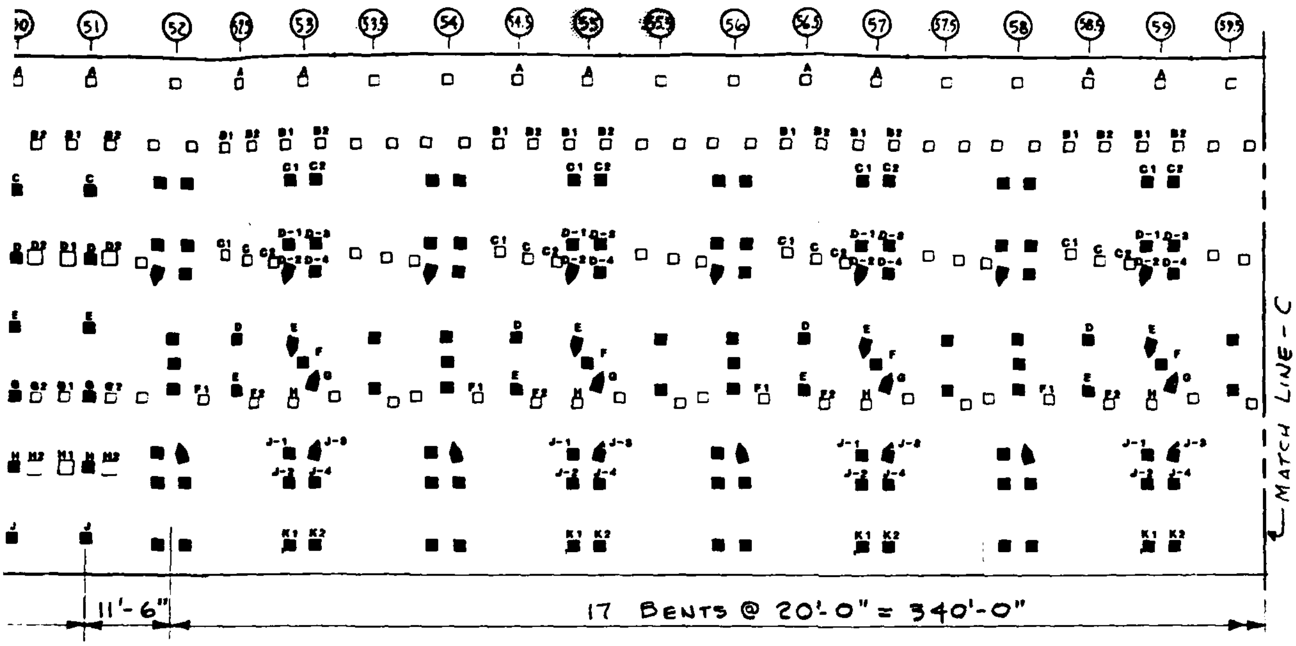


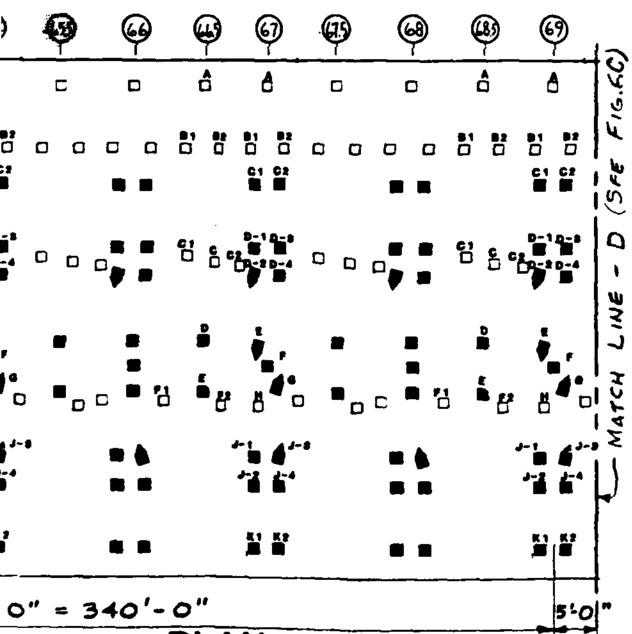
11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27
50 BENTS @ 10'-0" = 500'-0"
MATCH LINE - A
N
38 39
MATCH LINE - B (SEE FIG. 6B)
LEGEND
B2 - PILE DESIGNATION
4 - BENT NO.
- 16" SQ CONCRETE PILE
- 18" SQ CONCRETE PILE
- 26" SQ. CONCRETE PILE
- CONCRETE ENCASED STEEL H-PILE (HP12-53)
-16.0 - SOUNDING (MLW)
CLOSELY INSPECTED BENT. REMAINING BENTS GIVEN CURSORY "SWIM-BY" INSPECTION (SEE SECTION 3.2).
SIGNIFICANTLY DAMAGED PILE (SEE SECTION 4.1.2)
-16.0' -17.0' -18.0' -25.0'
1/4 1/2 3/4 1
-6.0' -25.0' -21.0' -28.0'
KEY PLAN
NOT TO SCALE
NOTE: BENT AND PILE DESIGNATIONS ARE ACCORDING TO CHESDIV STANDARDS.
-0"
PLAN
GRAPHIC SCALE
0' 10' 20' 30' 40'
Childs Engineering Corporation
CHESAPEAKE DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
WASHINGTON, D.C.
NAVAL SHIPYARD
CHARLESTON, SC
FIG. NO.
PIER DELTA
6A



PLAN

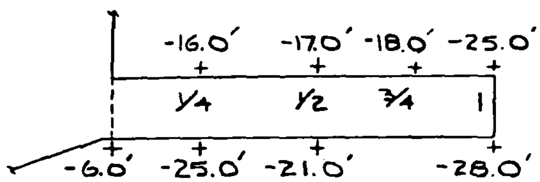
NOTE: BENT AND PILE DESIGNATIONS ARE ACCORDING TO CHESDIV STANDARDS.





PLAN

DESIGNATIONS ARE CHESDIV STANDARDS.



KEY PLAN
NOT TO SCALE

N

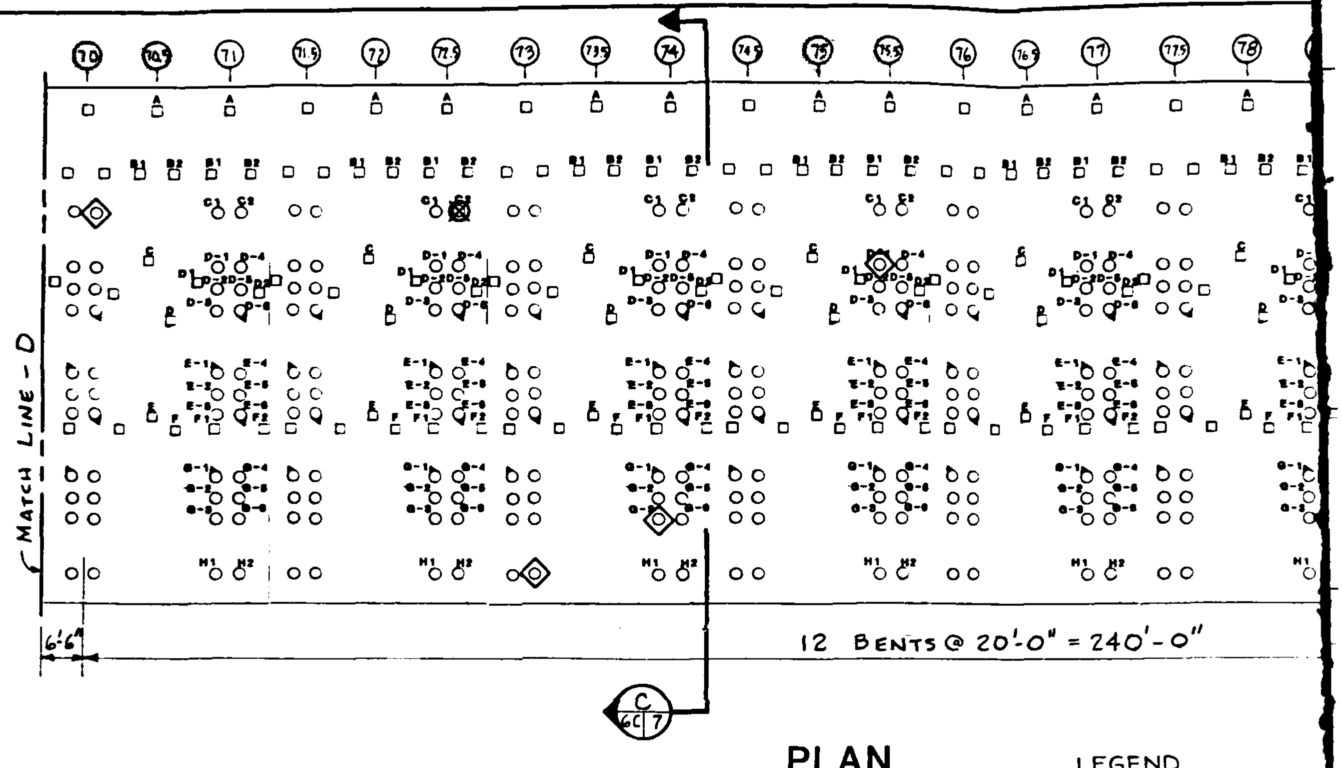
LEGEND

- B2 - PILE DESIGNATION
- (4) - BENT NO.
- ▫ - 16" SQ. CONCRETE PILE
- ■ - 18" SQ. CONCRETE PILE
- ☐ - 26" SQ. CONCRETE PILE
- O - CONCRETE ENCASED STEEL H-PILE (HP12×53)
- + -16.0' - SOUNDING (MLW)

(10) CLOSELY INSPECTED BENT. REMAINING BENTS GIVEN CURSORY "SWIM-BY" INSPECTION (SEE SECTION 3.2).

SIGNIFICANTLY DAMAGED PILE (SEE SECTION 4.1.2)

GRAPHIC SCALE		CHESAPEAKE DIVISION NAVAL FACILITIES ENGINEERING COMMAND WASHINGTON, D.C.	
0' 10' 20' 30' 40'	Childs Engineering Corporation Box 333 Medfield, MA	NAVAL SHIPYARD CHARLESTON, SC PIER DELTA	FIG. NO. 6B

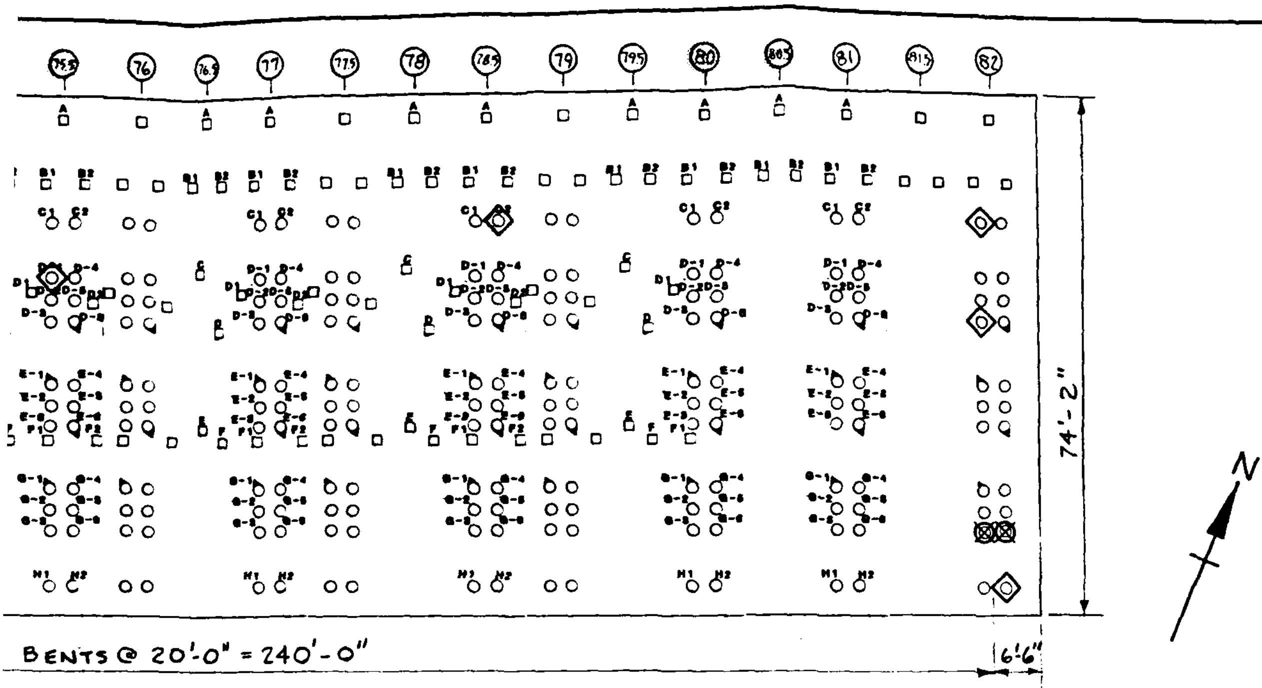


PLAN

LEGEND

B2 - PILE DESIGNATION
(4) - BENT NO.
□ - 16" SQ. CONCRETE PILE
■ - 18" SQ. CONCRETE PILE
□ - 26" SQ. CONCRETE PILE
O - CONCRETE ENCASED STEE
-16.0' - SOUNDING (MLW)
(10) CLOSELY INSPECTED B
BENTS GIVEN CURSOR
INSPECTION (SEE S
SIGNIFICANTLY DAMA
METAL THICKNESS

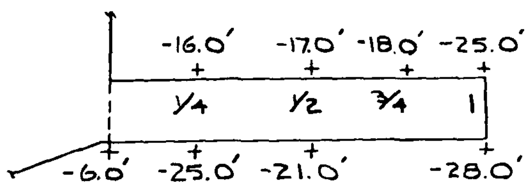
NOTE: BENT AND
ACCORDING



AN

LEGEND

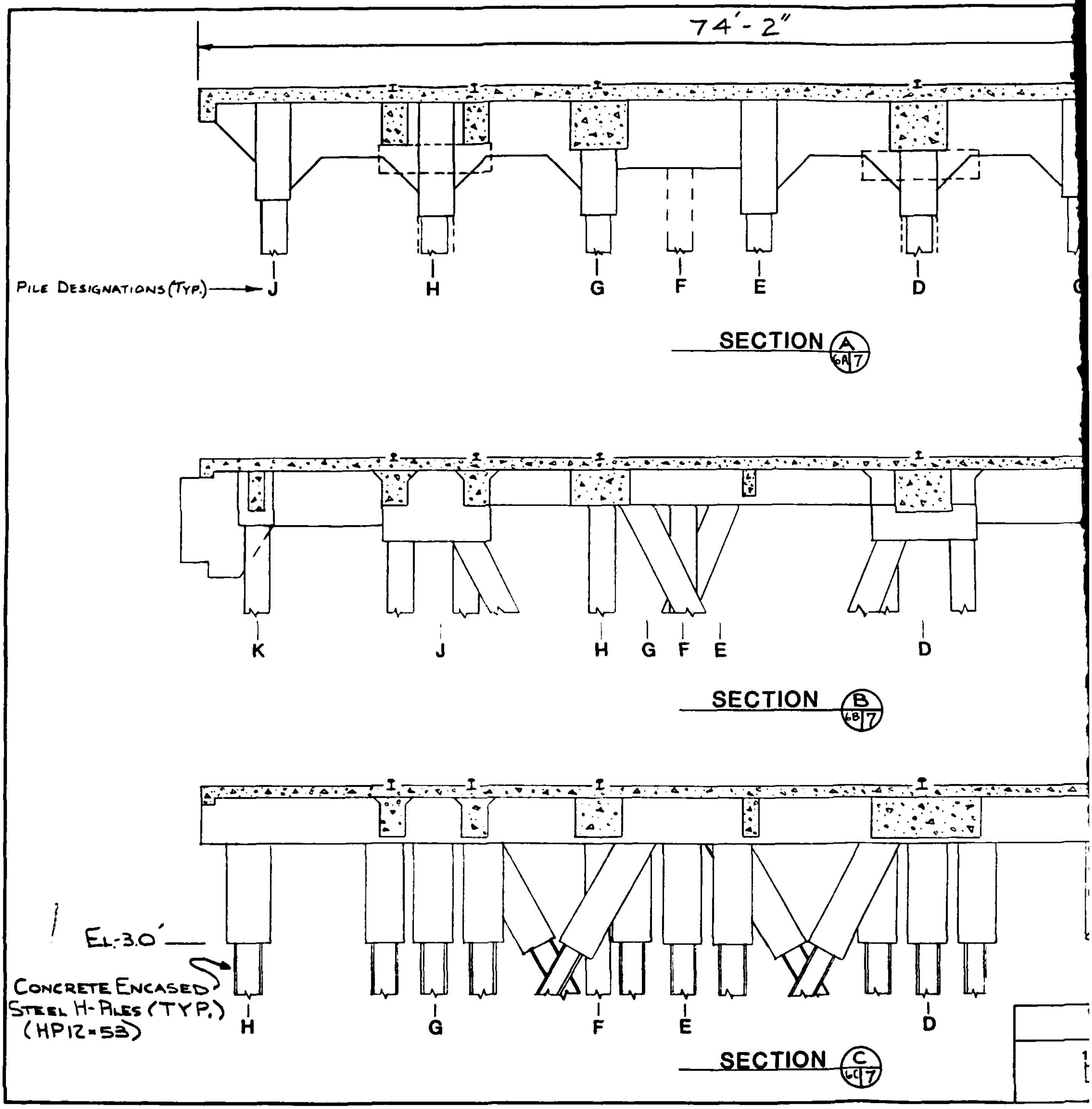
- Pile Designation
- Bent No.
- 16" Sq Concrete Pile
- 18" Sq Concrete Pile
- 26" Sq. Concrete Pile
- Concrete Encased Steel H-Pile (HP12·53)
- -16.0' Sounding (MLW)
- Closely Inspected Bent. Remaining Bents Given Cursory "Swim-By" Inspection (See Section 3.2).
- Significantly Damaged Pile (See Section 4.1.2)
- Metal Thickness Readings Taken (See Appendix)

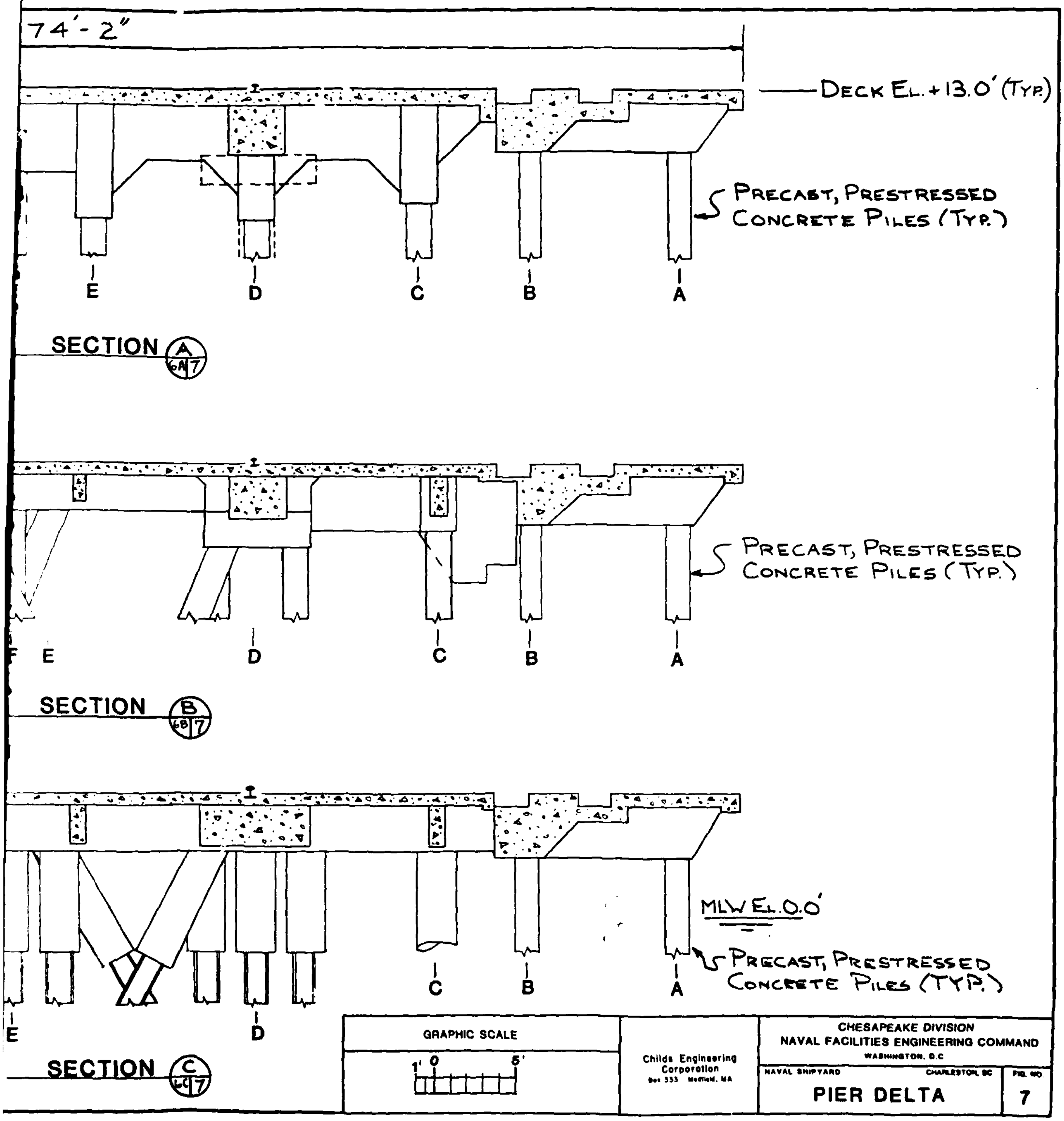


KEY PLAN
NOT TO SCALE

NOTE: Bent And Pile Designations Are According To CHESDIV Standards.

GRAPHIC SCALE	Childs Engineering Corporation, Box 333 Medfield, MA	CHESAPEAKE DIVISION NAVAL FACILITIES ENGINEERING COMMAND WASHINGTON, D.C.
0' 10' 20' 30' 40'		NAVAL SHIPYARD CHARLESTON, SC — PIER DELTA — FIG. NO. 6C


74'-2"
PILE DESIGNATIONS (TYP.)
J
H
G
F
E
D
SECTION A 6A 7
K
J
H
G
F
E
D
SECTION B 6B 7
EL-3.0'
CONCRETE ENCASED STEEL H-PILES (TYP.) (HP12×53)
H
G
F
E
D
SECTION C 6C 7


74'-2"
DECK EL. +13.0' (TYP.)
PRECAST, PRESTRESSED CONCRETE PILES (TYP.)
E
D
C
B
A
SECTION A 6A 7
PRECAST, PRESTRESSED CONCRETE PILES (TYP.)
F
E
D
C
B
A
SECTION B 6B 7
MLW EL. 0.0'
PRECAST, PRESTRESSED CONCRETE PILES (TYP.)
C
B
A
E
D
SECTION C 6C 7
GRAPHIC SCALE
1' 0 5'
Childs Engineering Corporation
Box 333 Medfield, MA
CHESAPEAKE DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
WASHINGTON, D.C
NAVAL SHIPYARD
CHARLESTON, SC
FIG. NO
PIER DELTA
7

4.1.2 Observed Inspection Condition

This section will be broken up into three increments. Each increment will correspond to the three different pier cross sections as shown in Figure 7. The first increment deals with Bent 1 through 51, the second with Bents 52 through 69 and the third with Bents 70 through 82.

In the first increment, the following typical conditions were observed:

1) All the 16" square utility piles (pile F) had cracks up to 1/8" wide and 1" deep in the tidal area;
2) About 1/2" of softness, spalling up to 2" deep and rounding of the corners of the concrete piles was common (see Photo #2);
3) A splice (cold form joint) was noted on 20% of H and J piles between Bents 25 and 40. These splices occurred between elevations +0.4' and +1.4'. Spalling of the concrete up to 4" deep and rust stains were associated with each splice;
4) Hairline cracks were observed in D1, D2 and H piles in the tidal area between Bents 40 through 50; and
5) Cracks up to 1/8" wide were observed in 80% of the H1 and H2 piles and 10% of H piles at elevation 0.0' (see Photo #3).

The following describes all structural anomalies noted in the first increment of Pier DELTA:

Bent	Pile	Elevation	Description
2	J	From +11.6' to -8.0'	1/4" wide crack.
31	C	+1.9'	Spalling on corner of concrete pile, 4" high and 3" deep, exposing steel reinforcing.
33	H	+3.4'	Splice (cold form joint); 1/2" wide by 1½" deep crack running through pile cap to head of pile; spalling 3" deep, 18" long (see Photo #4).
47	C	+1.4'	Spalling on corner of concrete pile, 18" high and 1½" deep; small crack and rusting observed.

PHOTO #3: Typical Cracking (Up to 1/8" Wide) Around Mean Low Water in the Concrete Piles in Bents 1-51 (Pier DELTA)

PHOTO #2: Example of Spalling (Up to 2" Deep) on Corner of Concrete Pile (Pier DELTA)

PHOTO #4: Splice (Cold Form Joint), Showing Cracking and Spalling in Bent 33, Pile H, at El. +3.4' (Pier DELTA)

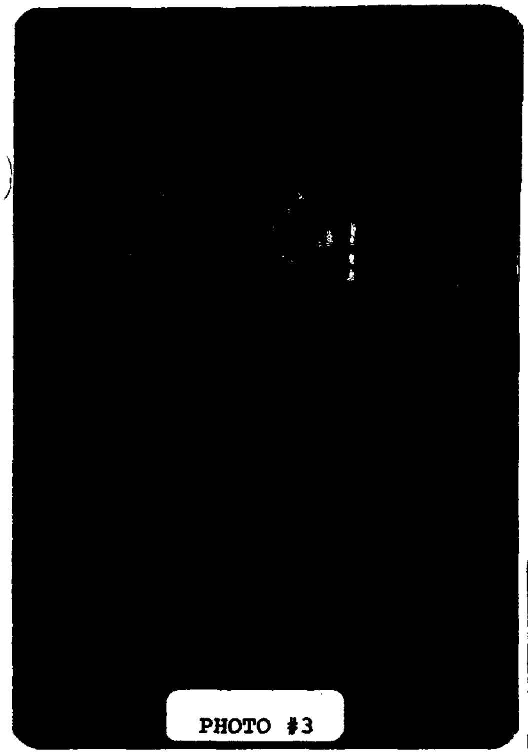


PHOTO #3

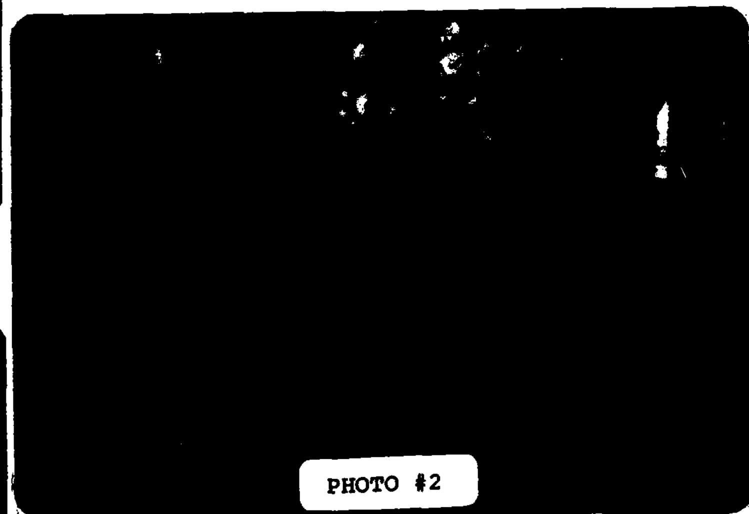


PHOTO #2

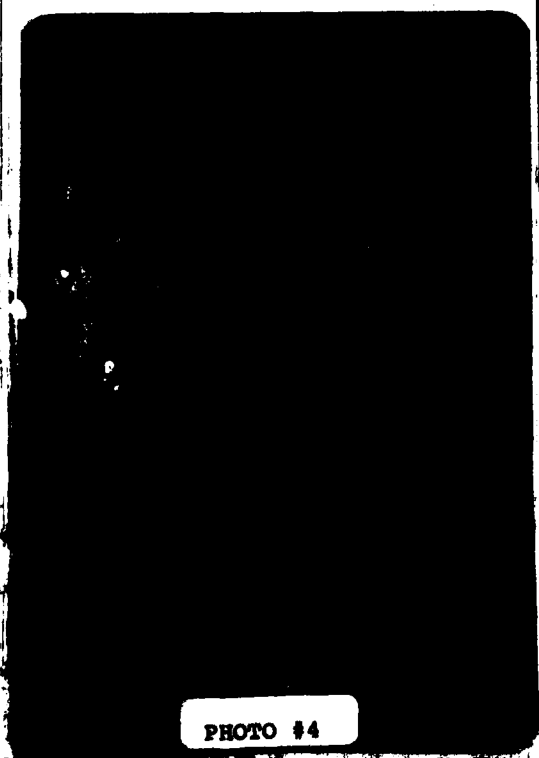


PHOTO #4

In the second increment of Pier DELTA, Bents 52 through 69, the following conditions were noted:

1) Hairline cracks were observed on 25% of the J and K piles around mean low water; and

2) On 80% of the E, F and G piles in the full bents and the D and E piles of the half bents, cracking up to 1/2" wide and spalling on the corners of the concrete piles, exposing steel reinforcing, was observed between elevations +8.6' and +5.6' (see Photo #5).

The last increment for Pier DELTA consists of Bents 70 through 82. Typical conditions observed in this increment include:

1) Gaps were observed in 60% of the concrete encasements for the steel H-piles between 1 and 3 feet above their bases (from elevations -1.7' to -3.7'). These gaps ranged in size from 3" to 36" high and encircled the concrete jacket. The steel reinforcing and the steel H-pile were exposed in this area. The concrete above and below these gaps was soft with very little aggregate visible (see Photo #10 under Pier HOTEL);

2) For the full length of exposed H-pile, pits up to 1" in diameter, with pinholes through the pile, were observed in areas of extensive marine growth (see Photo #6);

3) Within 2 feet of the bases of the concrete encasements, flanges of 30% of the steel H-piles thinned to a knife-edge (see Photo #7), often with variously sized bites taken out of the edges (see Photo #16 under Pier JULIET);

4) From Bents 75 through 82, 33% of the B piles had horizontal hairline cracks up to 14" long within 6" to 12" of the pile cap. Some leaching of calcium from the concrete was observed, but no rusting was visible;

PHOTO #5: Example of Cracking and Spalling of Pile Head with Steel Reinforcing Exposed (Pier DELTA)

PHOTO #6: Example of Pits (Up to 1" Diameter) in Steel H-Pile Flange (Pier DELTA)

PHOTO #7: Typical Thinning of *Flange to Knife-Edge* (Pier DELTA)

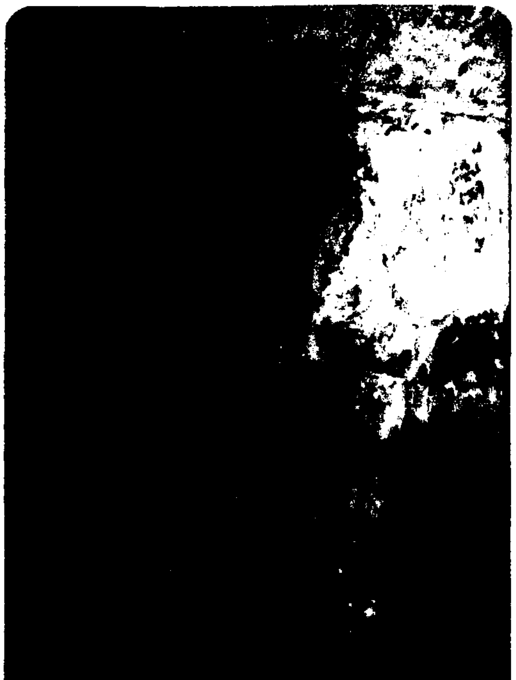


PHOTO #5

PHOTO #6

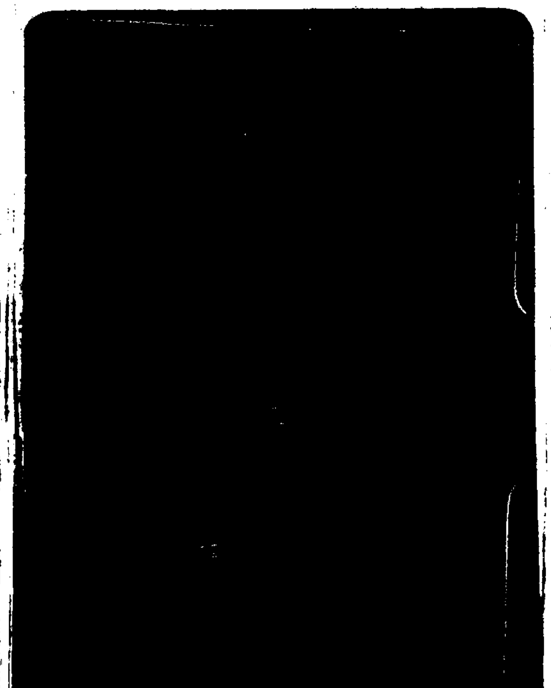


PHOTO #7

5) Ultrasonic steel thickness readings were taken on eight piles in this third increment between the base of the concrete encasement and the mudline. These readings indicated the remaining steel thickness to range from .240 to .430 inches; and

6) A caliper reading taken on the flange of one pile which was exposed by a gap in the concrete encasement around elevation -1.65' showed the remaining steel thickness to be .25 inches.

Other conditions observed in this third increment included:

Bent	Pile	Elevation	Description
72	C2	-6.7'	Steel H-pile flange buckled in 2 inches (see Photo #8).
82	G-6, G-3	+7.9' +4.9'	Crack in concrete jacket up to 1" in width (see Photo #9).

Soundings along the exterior faces of Pier DELTA indicated the water depth along the north face to range from elevations -16.0' to -25.0', and along the south face from -6.0' to -28.0'.

PHOTO #8: Buckled Flange Just Below Concrete Encasement in Bent 72, Pile C2 (Pier DELTA)

PHOTO #9: Crack (Up to 1" Wide) in Concrete Encasement at El. +7.9' in Pile G-6, Bent 82 (Pier DELTA)

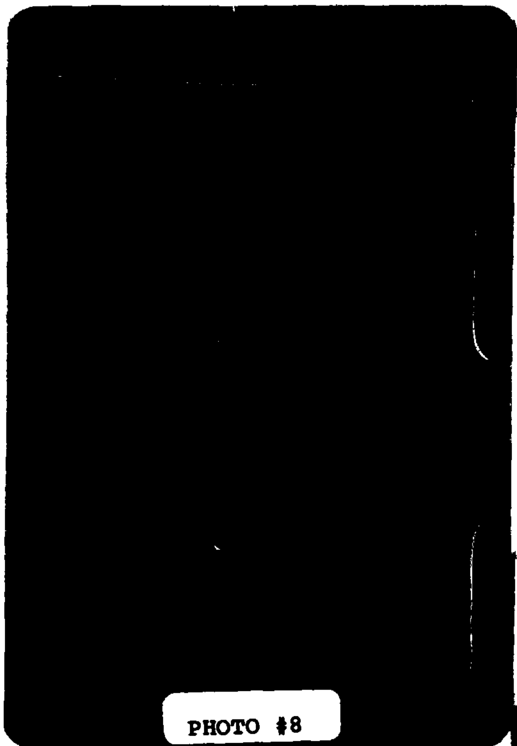


PHOTO #8

PHOTO #9

4.1.3 Structural Condition Assessment

In the first two increments of Pier DELTA, Bent 1 through Bent 69, cracking and spalling of the prestressed concrete piles were the only deterioration noted. Although this type of deterioration probably has not reduced the capacity of these piles at this time, continued spalling and cracking will cause eventual failure. Cracks in concrete provide access for water to get into the pile and to the reinforcing bars. Freezing of water and corrosion of the reinforcing cause the concrete cover to spall. This allows further ingress of salt water into the pile. Repairs to stop this continuing deterioration are the only solution.

For Bents 70 through 82, Pier DELTA is in a condition consistent with its age. The concrete jackets are in poor shape as evidenced by many gaps exposing the steel H-piles. Salt water corrosion has eroded away up to 45% of the original steel thickness. However, no structural irregularities were noted to cause Pier DELTA to be downgraded. Present pile conditions are adequate to carry the existing loads applied. Continued deterioration without preventive action will reduce capacities further.

Cracks in the concrete of the B piles do not represent a problem at this time. These cracks probably occurred during construction.

4.1.4 Recommendations

For Pier DELTA, it is recommended that all the decayed portions of both the concrete and the steel piles be repaired to prevent further deterioration.

The cracks greater than 1/32" wide in the concrete piles should be repaired by injecting an epoxy grout with a high pressure pump into the cracks. The estimated cost for this repair will be between $10,000 and $20,000. Similarly, the spalled portions of the concrete piles should be patched by applying an epoxy mortar mix over these areas. The cost for this repair is estimated to be between $30,000 and $50,000. Before repairing these areas, the cracks and spalled areas should be chipped and cleaned to sound concrete, and any exposed steel reinforcing should be cleaned or replaced if significantly deteriorated.

Pile C2 in Bent 72, which exhibited some buckling of the flanges, should be repaired by extending the concrete jacket to elevation -9.0', which is below the area of deflection. The estimated cost for this repair is $2,500.

Pier DELTA should be reinspected in three years to determine the further extent of deterioration. This report should be used as a baseline for this future inspection.

4.2 PIER HOTEL

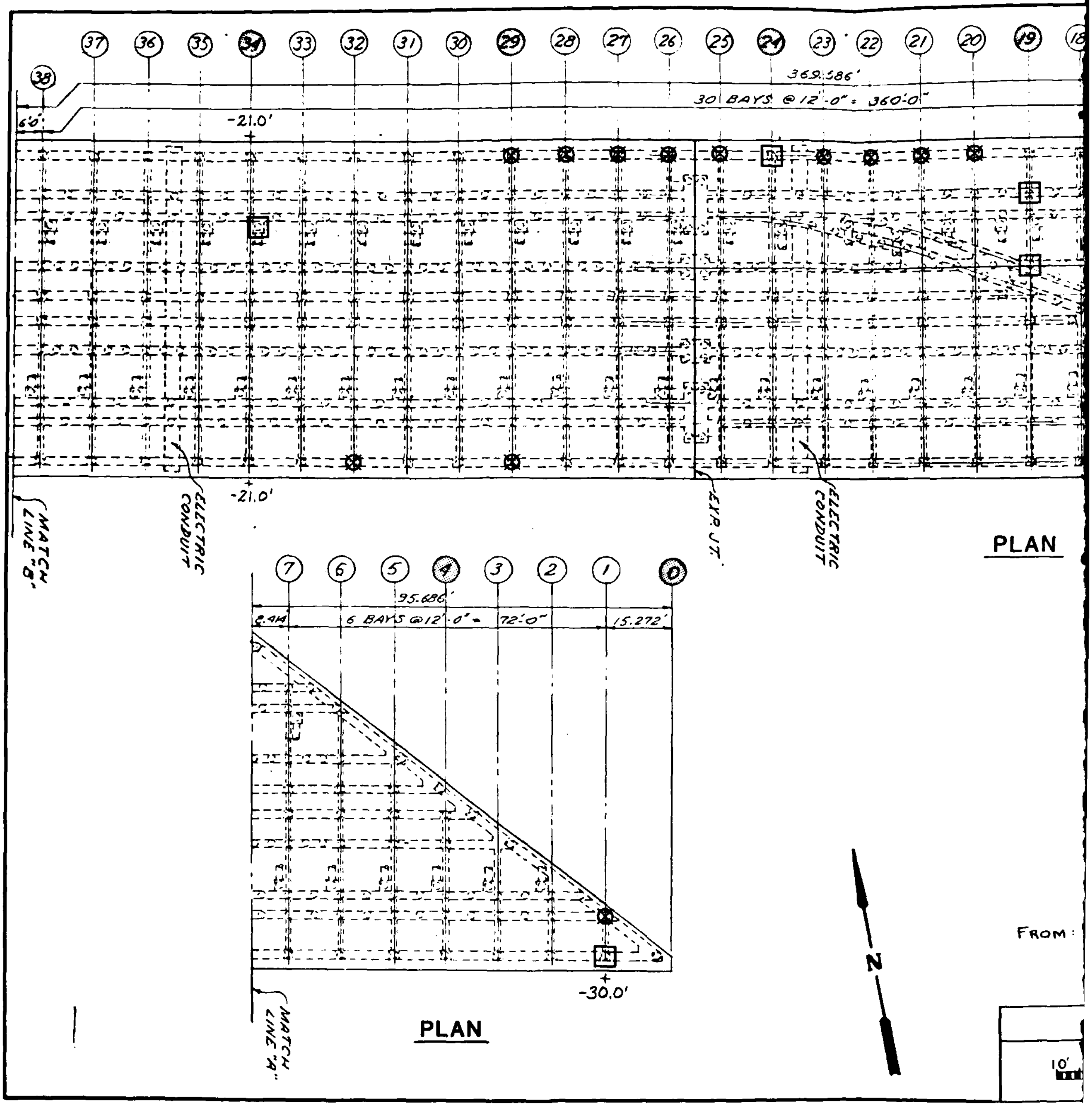
4.2.1 Description

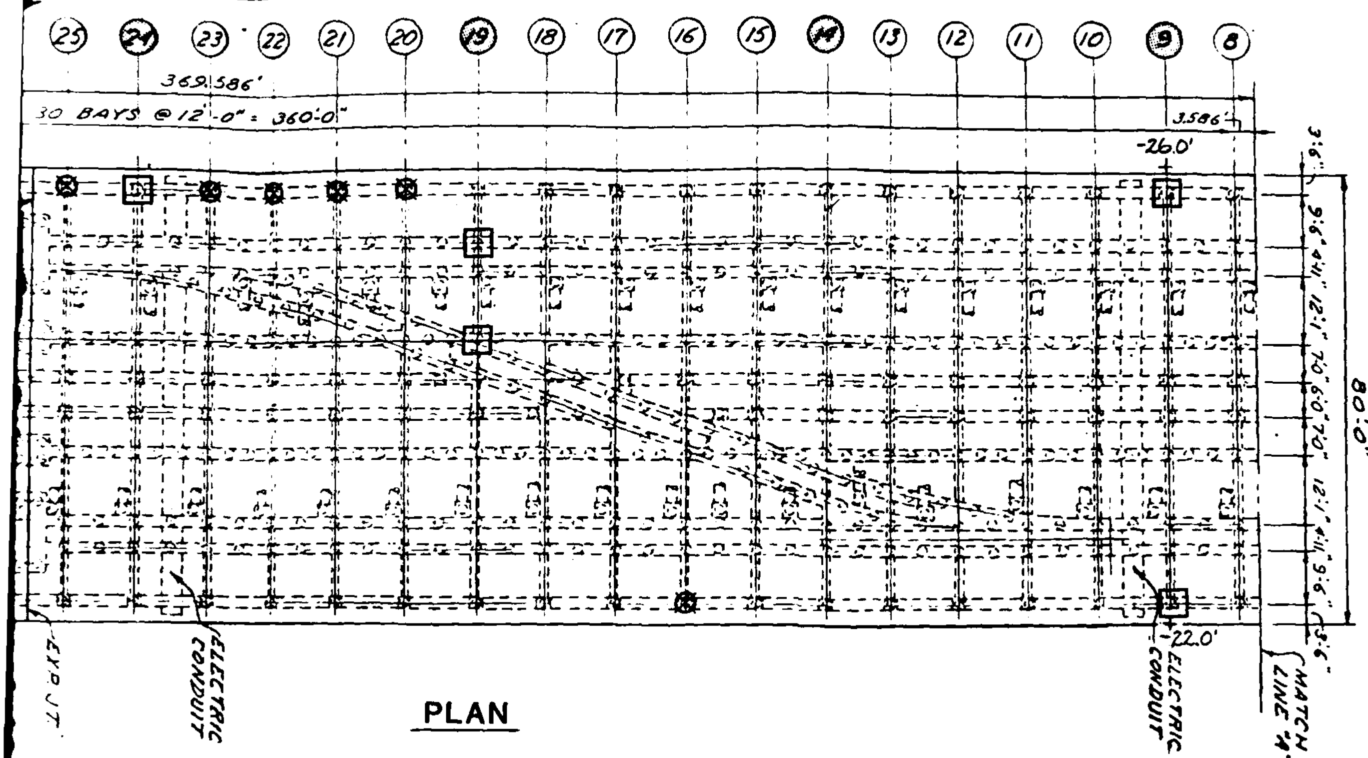
Pier HOTEL lies south of Pier DELTA in the Naval Shipyard and is adjacent to and just north of Pier JULIET. Located on the west bank of the Cooper River, it was functioning as the berthing area for an ARDM, a floating crane and several barges during the inspection period. The pier is provided with highway and railroad access and at least one portal crane.

Pier HOTEL was extended to its present plan around 1942 and was repaired around 1967. The 865' long x 80' wide pier is 71 bents long and heads in a easterly direction offshore, making a 39° angle with the downstream shoreline. The reinforced concrete deck is supported by steel HP12x53 piles with 24" diameter concrete jackets running from the pile cap to around -3.0' below mean low water (MLW). In all, there are 126 batter and 1248 vertical bearing piles (see Figures 8A and 8B). The piles have a design capacity of 40 tons. The design live load for the deck is 600 PSF in areas not occupied by cranes.

References: U.S. Navy Yard, Charleston, S.C.
"Piers 317-D, 317-E and 317-A Extension"
P.W. Dwg. #H317-1002, #H317-1003 and
#H317-1004

Charleston Naval Shipyard, Charleston, S.C.
"Structural Repairs to Piers F,G,H -
Pier H - Plan, Legend"
P.W. Dwg. #H317-1181


37 36 35 34 33 32 31 30 29 28 27 26 25 24 23 22 21 20 19 18
38
369.586'
30 BAYS @ 12'-0" = 360'-0"
6'0"
-21.0'
-21.0'
MATCH LINE "B"
ELECTRIC CONDUIT
EXP. JT.
ELECTRIC CONDUIT
PLAN
7 6 5 4 3 2 1 0
95.686'
6 BAYS @ 12'-0" = 72'-0"
15.272'
-30.0'
MATCH LINE "A"
PLAN
N
FROM:
10'



PLAN

LEGEND

(6) - Bent No.

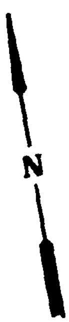
-35.0' - Sounding (MLW)

(19) - Closely Inspected Bent. Remaining Bents Given Cursory "Swim-By" Inspection (See Section 3.2)

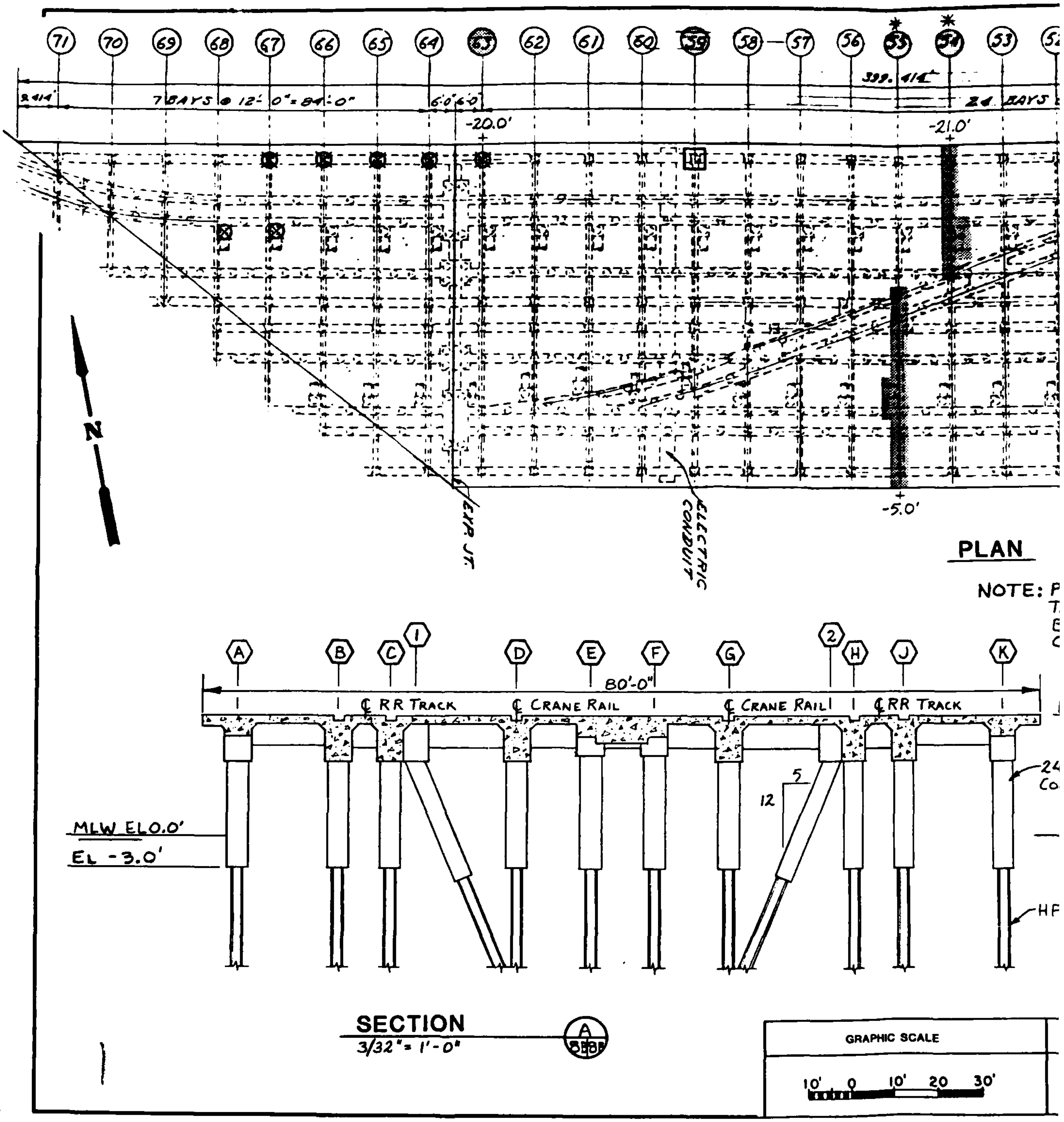
⊗ - Significantly Damaged Pile (See Section 4.2.2)

☐ - Metal Thickness Readings Taken (See Appendix)

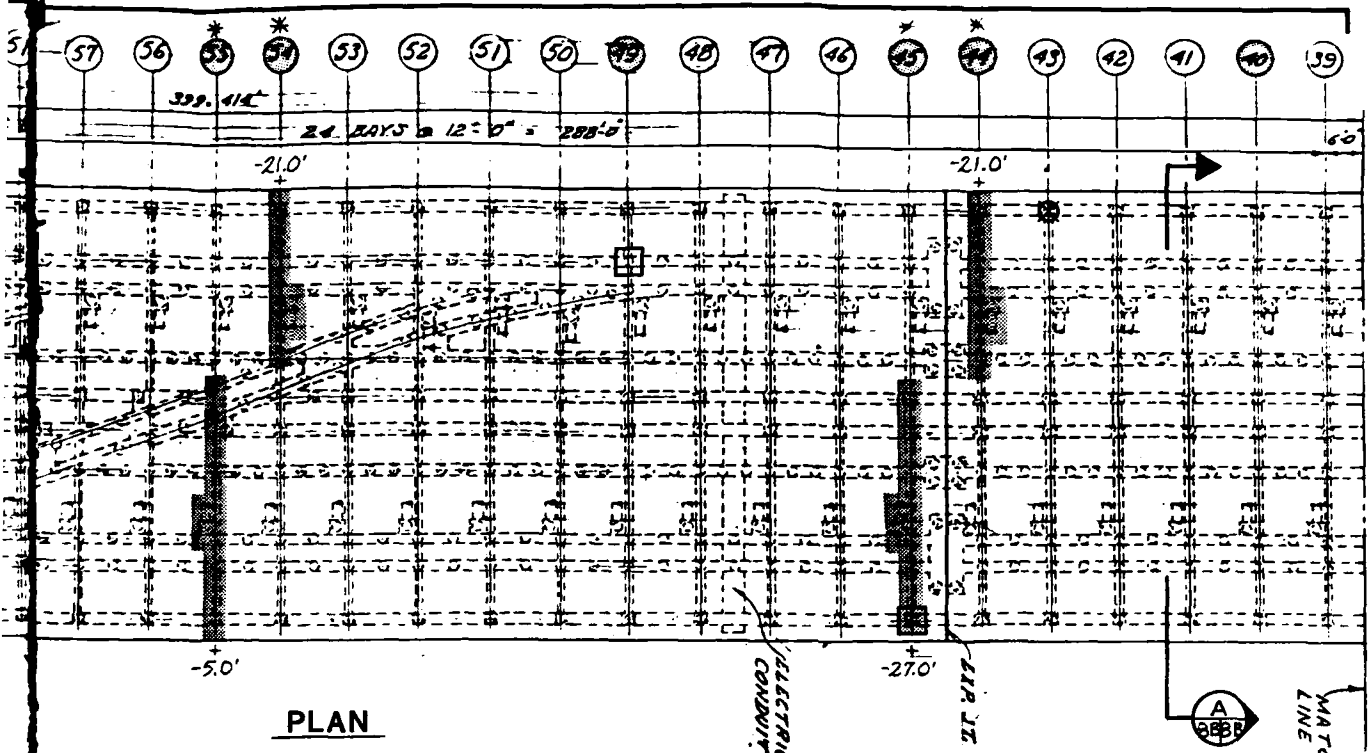
From: NAVFAC Dwg. No. 1139310.



GRAPHIC SCALE	Childs Engineering Corporation Box 333 Medfield, MA	CHESAPEAKE DIVISION NAVAL FACILITIES ENGINEERING COMMAND WASHINGTON, D.C.	
10' 0 10' 20 30'		NAVAL SHIPYARD CHARLESTON, SC PIER HOTEL	FIG NO. 8A

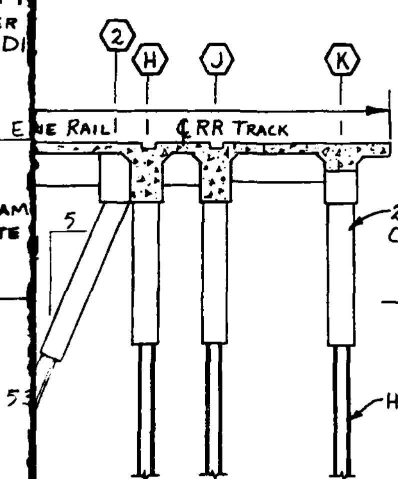


7 BAYS @ 12'-0" = 84'-0"
24 BAYS
-20.0'
-21.0'
-5.0'
N
EXP. JT.
ELECTRIC CONDUIT
PLAN
NOTE:
80'-0"
℄ RR TRACK
℄ CRANE RAIL
℄ CRANE RAIL
℄ RR TRACK
MLW EL 0.0'
EL -3.0'
SECTION
3/32" = 1'-0"
GRAPHIC SCALE
10' 0 10' 20 30'



PLAN

NOTE: PLAN AND VERTICAL PILE DESIGNATIONS TAKEN FROM NAVFAC DWG. NO. 1139310. BATTER PILE DESIGNATIONS TAKEN FROM CHESDIV STANDARDS.



LEGEND

(9) BENT NO.

(A) VERTICAL PILE DESIGNATION

(2) BATTER PILE DESIGNATION

+ -25.0' SOUNDING (MLW)

(19) - CLOSELY INSPECTED BENT. REMAINING BENTS GIVEN CURSORY "SWIM-BY" INSPECTION (SEE SECTION 3.2). IF STARRED(✱), ONLY SHADED PORTION OF BENT CLOSELY INSPECTED.

⊠ - SIGNIFICANTLY DAMAGED PILE (SEE SECTION 4.2.2)

⊡ - METAL THICKNESS READINGS TAKEN (SEE APPENDIX)

2

GRAPHIC SCALE	GRAPHIC SCALE		
10' 0 10' 20 30'	0 5' 10' 20' 3/32"=1'-0"	Childs Engineering Corporation Box 333 Medfield, MA	CHESAPEAKE DIVISION NAVAL FACILITIES ENGINEERING COMMAND WASHINGTON, D.C. NAVAL SHIPYARD CHARLESTON SC PIER HOTEL FIG. NO. 8B

4.2.2 Observed Inspection Condition

Throughout most of Pier HOTEL, the concrete encasements of the steel H-piles showed much deterioration. In 70% of these encasements, the lower four feet was often irregularly shaped, and contained many voids, and up to 2" of softness with no aggregate was common. In 35% of the piles, the voids or gap extended up to 18" high, exposing the steel reinforcing and the H-piles. These gaps were generally located within one to three feet of the base of the encasements, but sometimes were centered around mean low water (see Photo #10). The concrete in these areas was soft, contained no aggregate and could easily be chipped away with the hammer. The steel H-pile, where exposed, showed varying amounts of corrosion. Pits up to 1" in diameter were very common. The depths of the pits varied. In some cases they extended the thickness of the steel to pinholes (see Photo #6 under Pier DELTA). Flanges on 20% of the steel H-piles had thinned to a knife-edge (see Photo #7 under Pier DELTA). Bites up to 6" long and 4" deep were associated with these areas of thin flanges (see Photo #16 under Pier JULIET). Ultrasonic thickness measurements taken on nine individual piles indicated that the remaining steel thickness ranged from .240 inches to .540 inches.

Other conditions noted during our inspection of Pier HOTEL include:

Bent	Pile	Elevation	Description
1	J		Pile missing, broken from cap, laying on bottom (see Photo #11).
16	K		Pile missing, cut off at mudline.
20-23, 25,26, and 28	A	-4.0'	Pile buckled, 1/2" plate bolted over deflected area, 4 bolts per side, severe corrosion of threads; pile cap fractured, exposing steel reinforcing (see Photos #12 - #14).

PHOTO #10: Example of Gap in Concrete Encasement with Steel Reinforcing and H-Pile Exposed Around Mean Low Water (Pier HOTEL)

PHOTO #11: Fractured Pile Cap with Pile Missing in Bent 1, Pile J (Pier HOTEL)

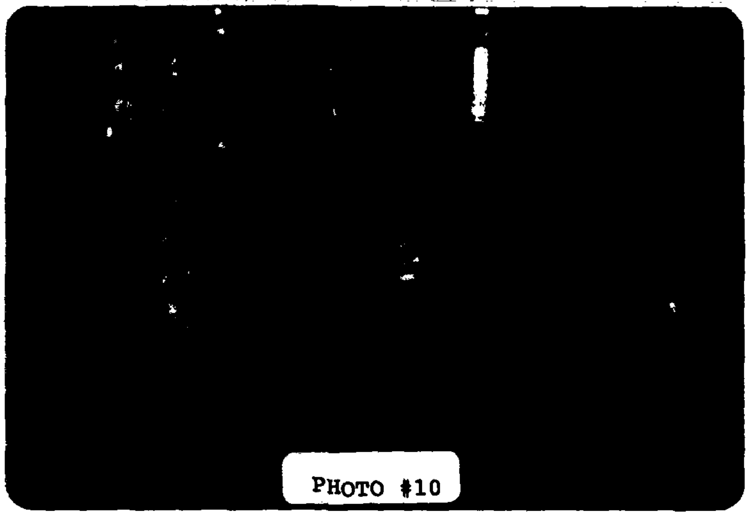


PHOTO #10

PHOTO #11

PHOTO #12: Typical Repair of Buckled Flange with 1/2" Plate Spanning Deflected Area (Pier HOTEL)

PHOTO #14: Example of Displaced Pile Head and Fractured Pile Cap (Pier HOTEL)

PHOTO #13: Repair of Buckled Flange Showing Typical Corrosion and Ineffectiveness of Bolted Connections (Pier HOTEL)

66

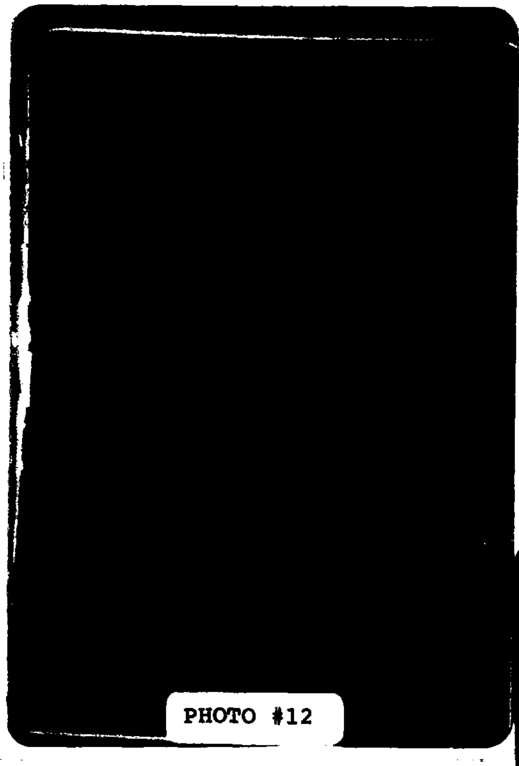


PHOTO #12

PHOTO #14

PHOTO #13

Bent	Pile	Elevation	Description
27	A	-4.0'	Same as Bent 20 (six bolts per side).
29	A	-4.0'	Same as Bent 20, no plate bolted over deflected area (see Photo #15).
29	K	+7.4'	Pile cap fractured; pile displaced from pile cap.
32	K	-2.0'	Six-inch gap in concrete encasement; flange buckled.
43	A	-3.0'	Flange buckled, pile cap fractured; no plate bolted over deflected area.
63-67	A	-3.5'	Flange buckled; pile head displaced from pile cap.
67,68	1	+7.4'	Fractured pile cap; 1" wide cracks on all sides.

Figure 9 shows a composite of some of the pile conditions found at Pier HOTEL.

Soundings taken at Pier HOTEL indicated the water depth to range from -5.0' to -30.0' below MLW on the south side, and from -20.0' to -26.0' below MLW on the north side.

PHOTO #15: Typical Buckling of Flange Just Below the Concrete Encasement at Pier HOTEL

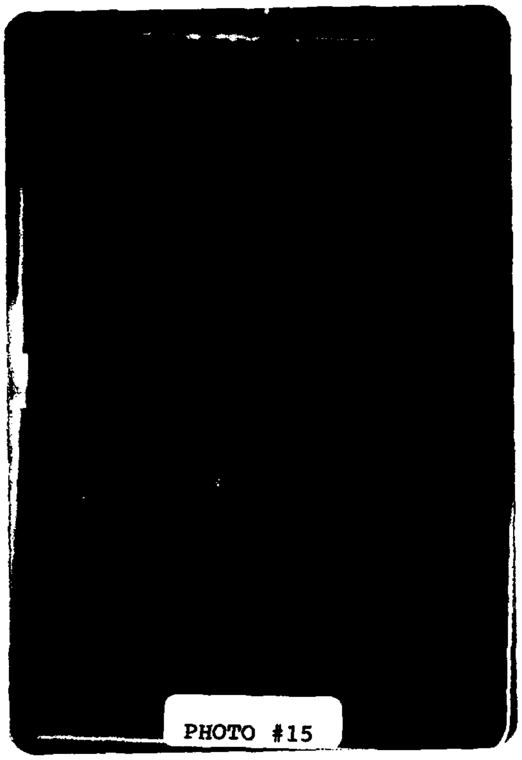
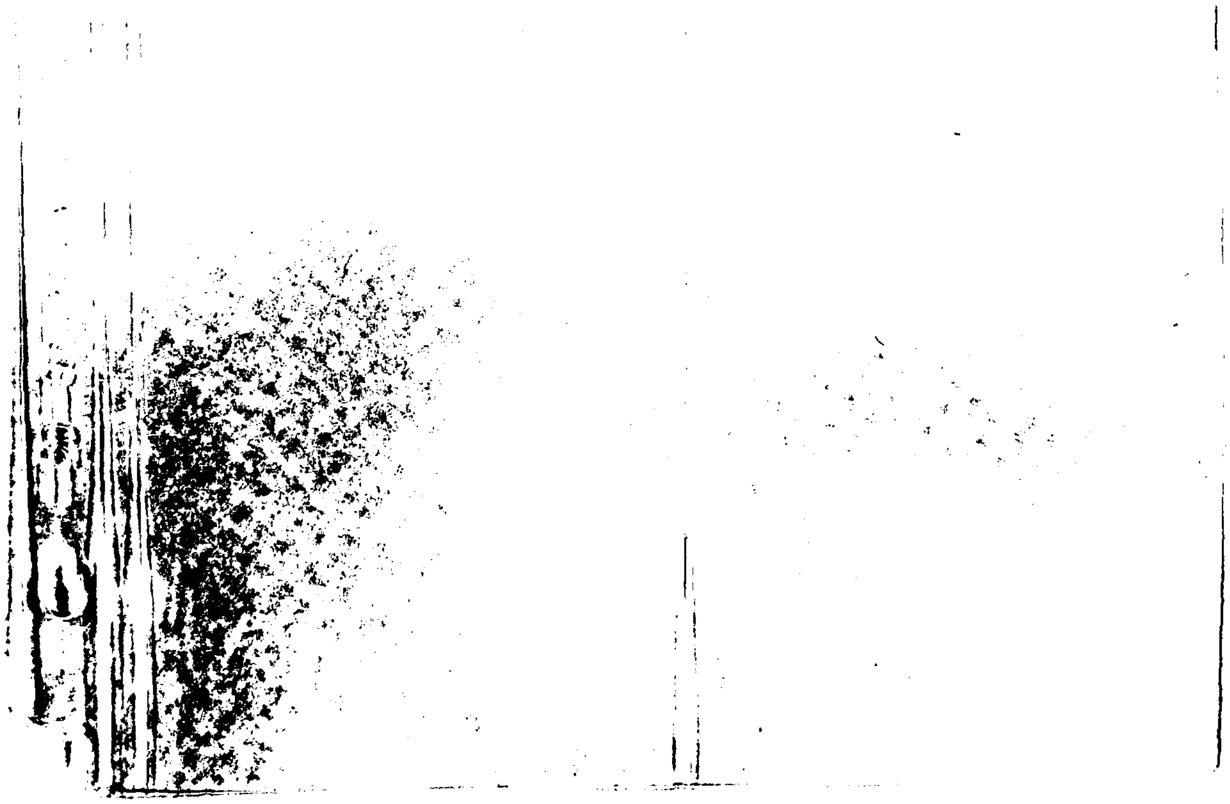
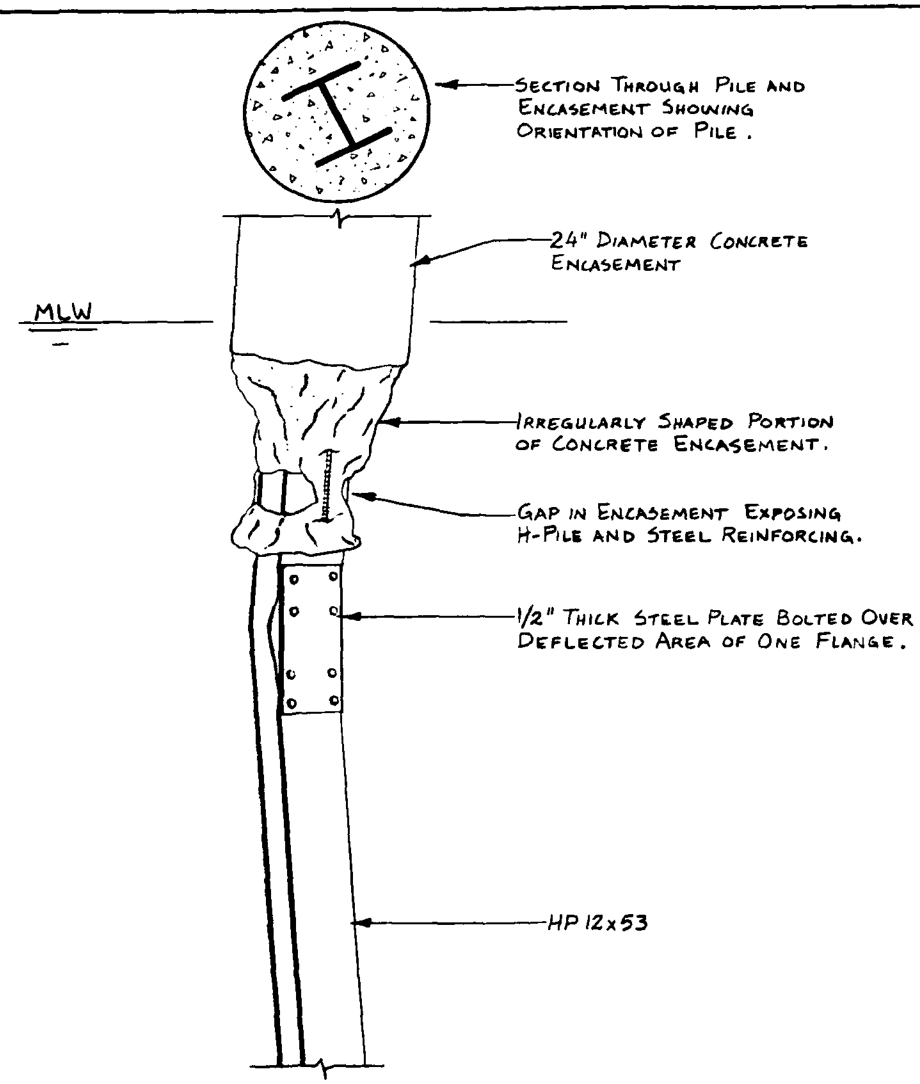


PHOTO #15





PILE CONDITIONS

GRAPHIC SCALE	Childs Engineering Corporation Box 333 Medfield, MA	CHESAPEAKE DIVISION NAVAL FACILITIES ENGINEERING COMMAND WASHINGTON, D.C.	
NOT TO SCALE		NAVAL SHIPYARD CHARLESTON, SC PIER HOTEL	FIG. NO. 9

4.2.3 Structural Condition Assessment

Pier HOTEL is in marginal condition. Below mean low water, the concrete jackets are in poor shape and are not protecting the steel piles from salt water corrosion. Also, 21 piles in Pier HOTEL are missing or buckled and/or fractured and displaced at the pile cap. This deterioration appears to have been caused by impact damage. Repairs have been made on some of the piles that have buckled, but these repairs have become ineffective.

Corrosion of the piles has occurred to such an extent that, in some areas, the flanges have thinned to a point where a portion of the flange can be knocked off with a hammer. Ultrasonic thickness readings indicate that up to 51% of the original steel thickness has been lost to corrosion. However, based on structural analysis calculations, the pile foundation, with the exception of the damaged and missing piles mentioned above, can still handle the imposed loads. Nevertheless, the piles supporting the 50-ton crane are approaching critical capacity due to the observed deterioration. Up to 50% of these piles may be in this near-critical condition.

Ultrasonic thickness readings indicate that, in some locations, HP12x74 piles probably were installed in this pier during its construction. Although the government-furnished information does not specify this addition, contractors have been known to substitute readily available material for scarce material, especially in construction projects immediately following World War II. This apparent substitution is not significant.

4.2.4 Recommendations

All piles either missing or buckled should be replaced with new steel pile posts. In the area of these piles, the pier loading should be reduced to dead load only until these piles are repaired. The estimated cost to replace these piles is $72,000.

It is recommended that the piles supporting the 50-ton crane which are approaching critical capacity (minimum cross-sectional area of 9.3 sq.in.) be repaired as soon as possible. This repair can be accomplished by encasing the piles in 24" diameter concrete jackets from the sound portion of the existing concrete jackets to elevation -10.0'. The estimated cost for this repair is $95,000.

Pier HOTEL should be reinspected in three years. Piles approaching their critical capacities at that time should be similarly repaired. This report should be used as a baseline for this future inspection.

4.3 PIER JULIET

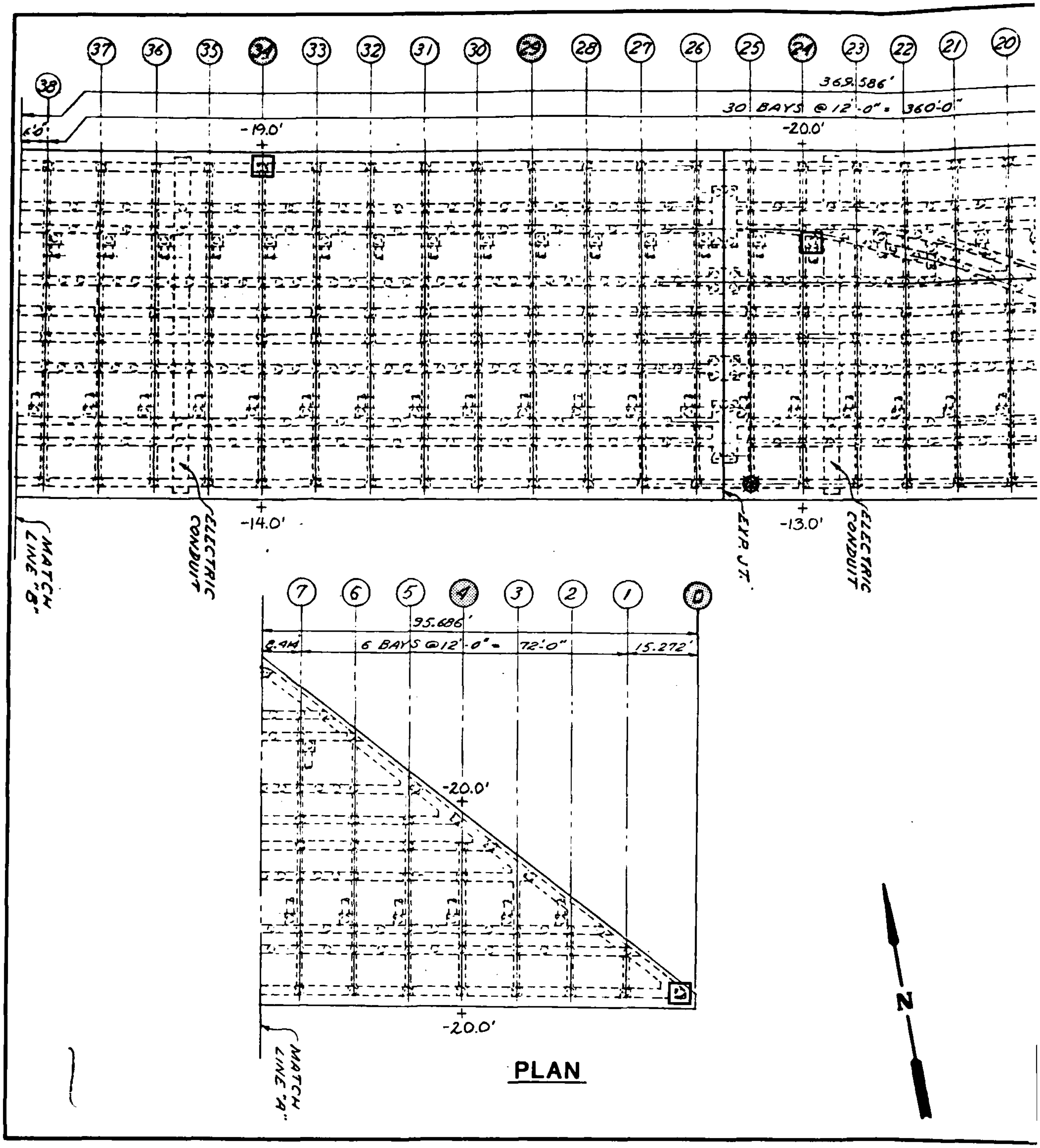
4.3.1 Description

Pier JULIET is located just south of Pier HOTEL in the Naval Shipyard and north of Pier KILO in the Naval Station. Situated on the west bank of the Cooper River, it was idle during the time of the inspection, although it has berthing capabilities similar to Pier HOTEL. The pier is provided with highway and railroad access and at least one portal crane.

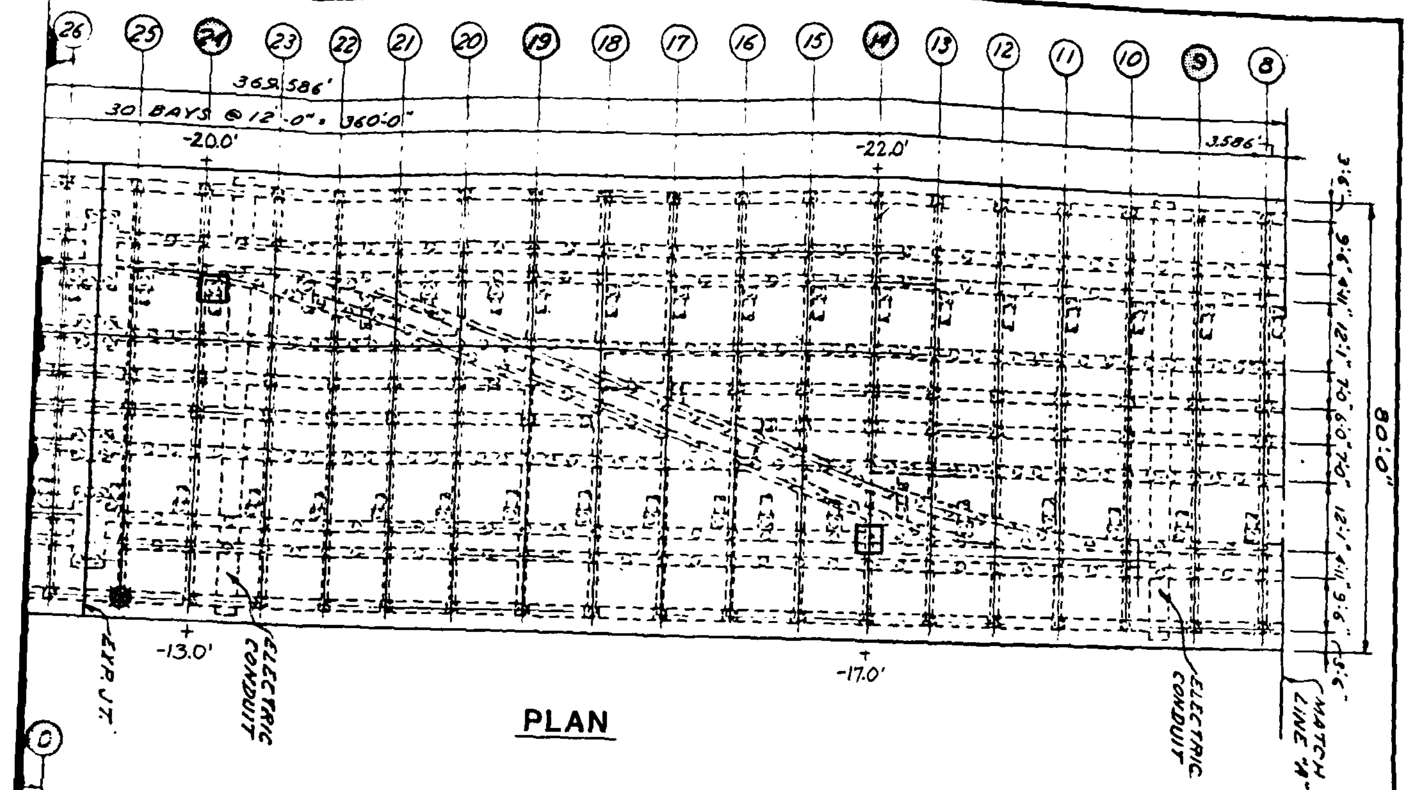
Pier JULIET was probably built or extended to its present plan around 1942 and was repaired around 1971. The 865' long x 80' wide pier is 71 bents long and heads in an easterly direction offshore, making a 39° angle with the downstream shoreline. The reinforced concrete deck is supported by steel HP12x53 piles with 24" diameter concrete jackets running from the pile cap to around -3.0' below mean low water (MLW). In all there are 126 batter and 1248 vertical bearing piles (see Figures 10A and 10B). The design data for Pier JULIET are probably the same as for Pier HOTEL - i.e., the piles have a design capacity of 40 tons, and the deck has a design live load of 600 PSF in areas not occupied by cranes.

References: U.S. Navy Yard, Charleston, S.C.
"Piers 317-D, 317-E and 317-A Extension"
P.W. Dwg. #H317-1002 and #H317-1003

Southern Division, Naval Facilities Engineering Command
"Modernize Pier "J" (317-F)"
NAVFAC Dwg. #5016480, #5016481 and #5016482


38
37
36
35
34
33
32
31
30
29
28
27
26
25
24
23
22
21
20
369.586'
30 BAYS @ 12'-0" = 360'-0"
-19.0'
-20.0'
-14.0'
-13.0'
MATCH LINE "B"
ELECTRIC CONDUIT
EXP. JT.
ELECTRIC CONDUIT
7
6
5
4
3
2
1
0
95.686'
6 BAYS @ 12'-0" = 72'-0"
15.272'
-20.0'
-20.0'
MATCH LINE "A"
N

PLAN



PLAN

LEGEND

(2) Bent No.

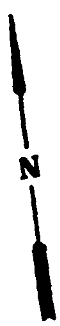
+ -30.0' Sounding (MLW)

(19) - Closely Inspected Bent. Remaining Bents Given Cursory "Swim-By" Inspection (See Section 3.2)

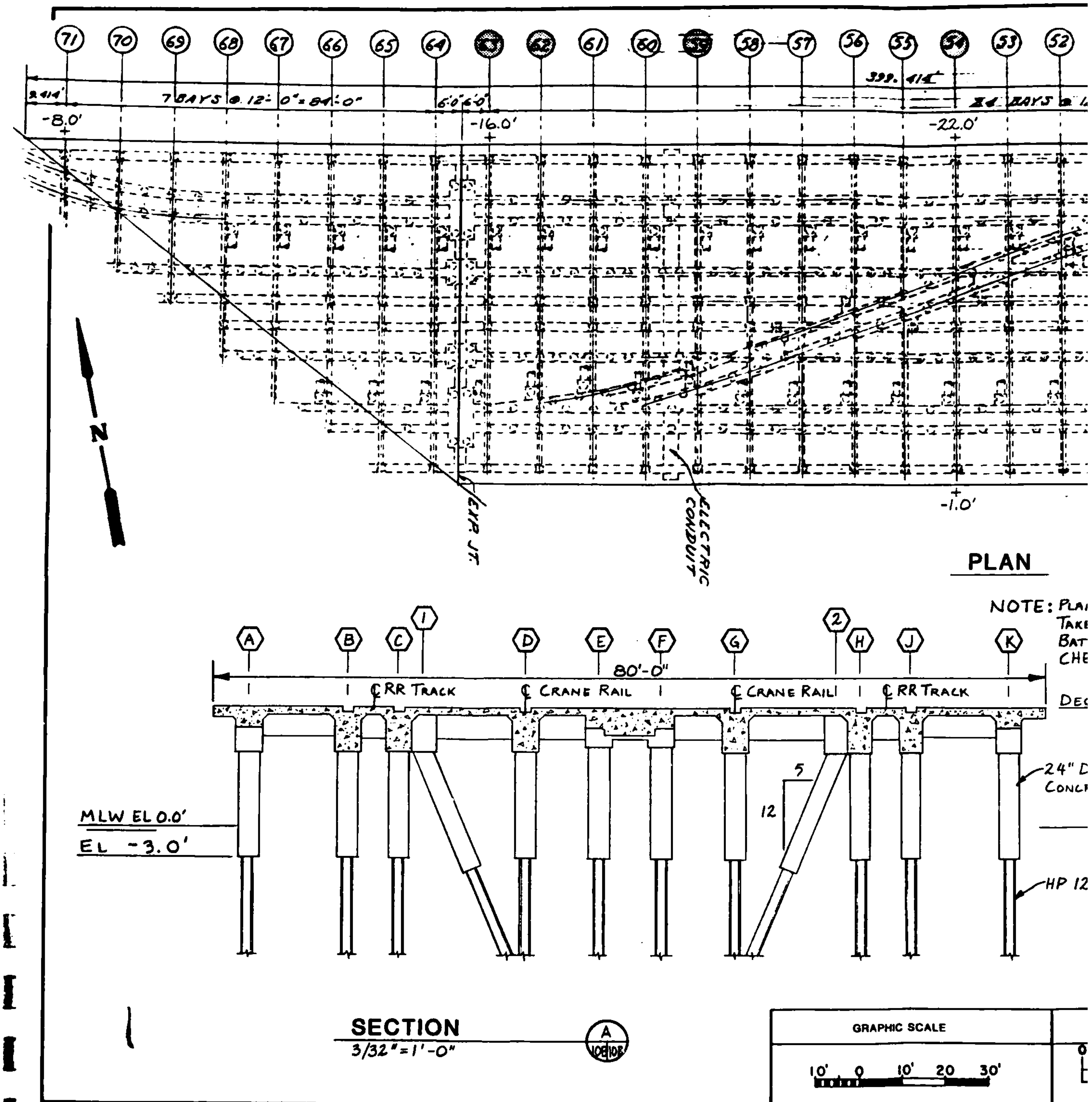
⊗ - Significantly Damaged Pile (See Section 4.3.2)

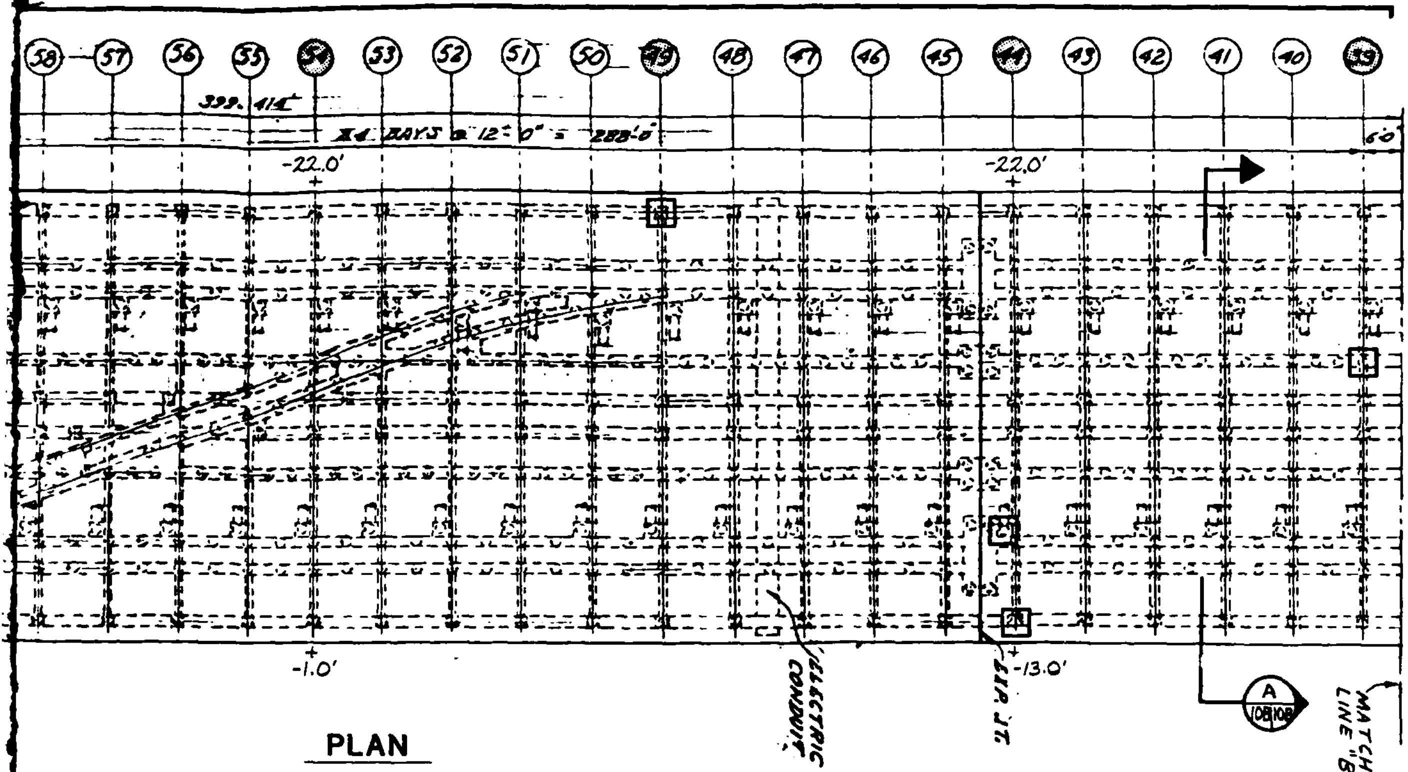
▢ - Metal Thickness Readings Taken (See Appendix)

From: NAVFAC Dwg. No. 1139310.



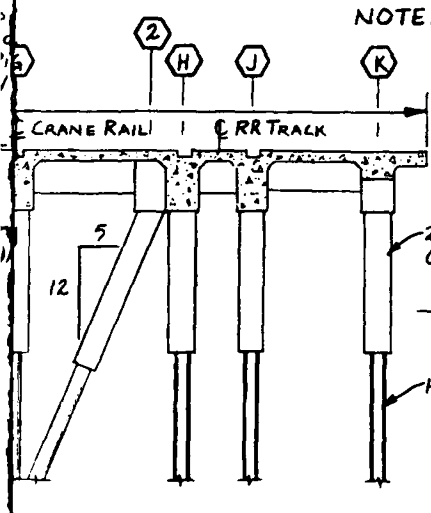
GRAPHIC SCALE	Childs Engineering Corporation Box 333 Medfield, MA	CHESAPEAKE DIVISION NAVAL FACILITIES ENGINEERING COMMAND WASHINGTON, D.C.		
10' 0 10' 20 30'		NAVAL SHIPYARD	CHARLESTON, SC	FIG NO.
		PIER JULIET		10A


PLAN
NOTE:
SECTION
3/32" = 1'-0"
GRAPHIC SCALE
10' 0 10' 20 30'
80'-0"
RR TRACK
CRANE RAIL
CRANE RAIL
RR TRACK
MLW EL 0.0'
EL -3.0'
EXP. JT.
ELECTRIC CONDUIT
7 BAYS @ 12'-0" = 84'-0"
-8.0'
-16.0'
-22.0'
-1.0'



PLAN

NOTE: PLAN AND VERTICAL PILE DESIGNATIONS TAKEN FROM NAVFAC DWG. NO. 1139310. BATTER PILE DESIGNATIONS TAKEN FROM CHESDIV STANDARDS.



LEGEND

- (7) BENT NO.
- (B) VERTICAL PILE DESIGNATION
- (2) BATTER PILE DESIGNATION
- -17.0' SOUNDING (MLW)
- (19) - CLOSELY INSPECTED BENT. REMAINING BENTS GIVEN CURSORY "SWIM-BY" INSPECTION (SEE SECTION 3.2)
- ☐ - METAL THICKNESS READINGS TAKEN (SEE APPENDIX)

GRAPHIC SCALE	GRAPHIC SCALE		CHESAPEAKE DIVISION NAVAL FACILITIES ENGINEERING COMMAND WASHINGTON, D.C.
10' 0 10' 20 30'	0 5' 10' 20' 3/32"=1'-0"	Childs Engineering Corporation Box 333 Medfield, MA	NAVAL SHIPYARD CHARLESTON, SC FIG. NO. PIER JULIET 10B

4.3.2 Observed Inspection Condition

Like Pier HOTEL, 70% of the concrete encasements have experienced much deterioration. In 35% of these jackets, voids up to 18" in height, encircling the entire pile, were recorded. The concrete was soft, and the steel reinforcing and the steel H-pile were visible (see Photo #10 under Pier HOTEL). These gaps usually occurred within one to three feet above the bottom of the encasement (El. -2.0' to 0.0').

Corrosion at Pier JULIET was extensive. Ultrasonic steel thickness measurements revealed that between .235 inches and .510 inches of steel still remained. Pits up to 2" in diameter occasionally necking down to pinholes through the pile were common (see Photo #6 under Pier DELTA). Flanges on 35% of the piles have thinned to a knife-edge (see Photo #7 under Pier DELTA). Bites up to 6" long and 3" deep were often associated with thinning flanges (see Photo #16). On one pile (Bent 51, Pile B, El. -4.0'), the flange could be knocked away with a hammer to a depth of 5 inches.

The only other structural anomaly was observed at Bent 25, Pile K and was centered at El. -5.0'. At this point, the south flange of the steel H-pile was wavy for 24" of its length.

Soundings indicated water depths to range from -1.0' to -20.0' (MLW) on the south side and from -8.0' to -22.0' (MLW) on the north side.

PHOTO #16: Typical Corrosion Bite (1½" Deep, 1½" High) Just Below Concrete Encasement (Pier JULIET)

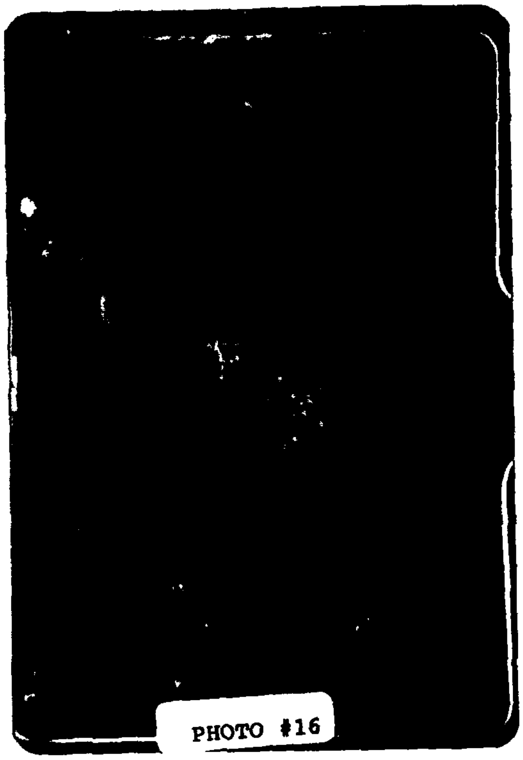


PHOTO #16

4.3.3 Structural Condition Assessment

Pier JULIET is in marginal condition. Below mean low water, many of the concrete jackets are not protecting the steel H-pile from salt water corrosion. Ultrasonic thickness readings indicate that up to 54% of the original steel thickness has been lost to corrosion. However, based on structural analysis calculations, the pile foundation can still handle the imposed loads. Nevertheless, the piles supporting the 50-ton crane are approaching critical capacity due to the observed deterioration. Up to 38% of these piles may be in this near-critical condition.

The wavy flange on Pile K in Bent 25 appears to have been caused by impact damage rather than an overload condition.

Ultrasonic thickness readings indicate that, in some locations, HP12x74 piles probably were installed in this pier during its construction. Although the government-furnished information does not specify this addition, contractors have been known to substitute readily available material for scarce material, especially in construction projects immediately following World War II. This apparent substitution is not significant.

4.3.4 Recommendations

Pile K in Bent 25 should be replaced with a new steel pile post. In the area of this pile, the pier loading should be reduced to dead load only until it is repaired. The estimated cost to replace this pile is $3,400.

It is recommended that the piles supporting the 50-ton crane which are approaching critical capacity (minimum cross-sectional area of 9.3 sq. in.) be repaired as soon as possible. This repair can be accomplished by encasing the piles in 24" diameter concrete jackets from the sound portion of the existing concrete jackets to elevation -10.0'. The estimated cost for this repair is $72,000.

Pier JULIET should be reinspected in three years. Piles approaching their critical capacities at that time should be similarly repaired. This report should be used as a baseline for this future inspection.

TABLE OF CONTENTS FOR APPENDIX

FOOTNOTES

1. CHARLESTON NAVAL COMPLEX MASTER PLAN; Southern Division, Naval Facilities Engineering Command, p. III-18.

2. Ibid, pp. III-18 and III-19.

3. Ibid, p. IV-19.

4. Ibid, p. II-16.

5. Ibid, p. IV-25.

6. Ibid, p. IV-25.

REPAIR COST ESTIMATE

PIER DELTA

1) Repair cracks in concrete piles by filling cracks with epoxy grout:
   - A) Chip to sound concrete, clean exposed steel and concrete and inject grout with high pressure pump:
     $40/LF*x 275LF of cracks = $11,000

2) Patch spalled areas on piles with epoxy mortar mix:
   - A) Chip to sound concrete, clean exposed steel and concrete and patch:
     $15/SF* x 2000SF = $30,000

3) Protect steel H-pile from further corrosion by encasing the H-pile in 28" diameter concrete jacket from sound portion of the existing concrete jacket to elevation -9.0':
   - A) Remove existing deteriorated concrete jacket, clean pile, add steel reinforcing and encase with new 28" diameter concrete jacket to elevation -9.0':
     Lump Sum = $ 2,500

*Costs are taken from CEC Report for U.S. Navy, Civil Engineering Laboratory, on "Survey of Techniques for Underwater Maintenance/ Repair of Waterfront Structures", February 1980.

REPAIR COST ESTIMATE

PIER HOTEL

1) Replace all damaged H-piles with new pile posts (HP12x53):
   A) Total Cost:
      21 piles x \$3,400/pile = \$72,000

2) Protect severely deteriorated steel H-piles supporting 50-ton crane from further corrosion by encasing in 24" diameter concrete jackets from sound portion of the existing concrete jackets to elevation -10.0':
   A) Remove existing deteriorated concrete jackets, clean pile, add steel reinforcing and encase in concrete:
      \$600/cy concrete x .126 cy/ft x 7ft/pile x 178 piles =
      \$95,000

REPAIR COST ESTIMATE

PIER JULIET

1) Replace all damaged H-piles with new pile posts (HP12x53):
   - A) Total Cost:
     1 pile x $3,400/pile = $ 3,400

2) Protect severely deteriorated steel H-piles supporting 50-ton crane from further corrosion by encasing in 24" diameter concrete jackets from sound portion of the existing concrete jackets to elevation -10.0':
   - A) Remove existing deteriorated concrete jackets, clean pile, add steel reinforcing and encase in concrete:
     $600/cy concrete x .126 cy/ft x 7 ft/pile x 135 piles =
     $72,000

PIER DELTA - COLUMN ANALYSIS

[Refer to Childs Engineering Report entitled "Analysis of the Remaining Strength of Concrete Jacketed Steel H-Piles", Feb. 1982]

Assumption: Steel is A-7 ($F_Y = 33$ KSI)

Definition of Terms:

K = Factor Based on Column End Conditions (see Chart in Report)

$K' = \frac{1}{\sqrt{K}}$

ℓ = Length of Column from Pile Cap to Mudline + 5' (in.)

ℓ_e = Effective Column Length = $K'\ell$

I_r = Average Remaining Moment of Inertia of Column about its Y-Y Axis (in.^{4})

E_t = Tangent Modulus (see Chart in Report)

A_r = Average Remaining Cross-Sectional Area of Column (in.^{2})

r_r = Average Remaining Radius of Gyration of Column = $\sqrt{I_r/A_r}$ (in.)

Web_r = Average Remaining Web Thickness (in.)

A/ℓ = Ratio of length of Concrete Jacket (A) to Overall length of Column (ℓ) - (see Chart in Report)

Fl_r = Average Remaining Flange Thickness (in.)

$\frac{E_2I_2}{E_1I_1}$ = Ratio relating the stiffness of the column encased in a concrete jacket (E_2I_2) to the stiffness of the Exposed Column (E_1I_1) - (see Chart in Report)]

σ_{cr} = Critical Column Buckling Stress (KSI) - (see Chart in Report)

P_{cr} = Overall Column Buckling Load (Factor of Safety not Included) - (K)

Note: The columns investigated are in the inelastic buckling range ($\ell e/r < C_c = 133.1$), so the tangent modulus, E_t, must be used to calculate P_{cr} and σ_{cr}:

$$\sigma_{cr} = \frac{K\pi^2 E_t}{(\ell/r)^2} = \frac{\pi^2 E_t}{(\ell e/r)^2} \qquad P_{cr} = \frac{K\pi^2 E_t I}{\ell^2} = (\sigma_{cr})(A_r)$$

PILE	73-H2	74-G-3	75-D-1	70-C2	78-C2	82-D-3	82-C1	82-H2
TYPE	HP 12x53	→	→	→	→	→	→	→
Web_r (in)	.294	.340	.328	.346	.378	.359	.349	.372
Fl_r (in.)	.367	.334	.330	.369	.350	.375	.404	.344
A_r (in^2)	12.05	11.76	11.53	12.66	12.56	12.95	13.54	12.35
I_r (in^4)	106.9	97.3	96.1	107.5	102.0	109.2	117.7	100.2
r_r (in)	2.98	2.88	2.89	2.91	2.85	2.90	2.95	2.85
ℓ (in)	412	376	334	364	406	460	502	520
A/ℓ	.36	.39	.44	.41	.36	.32	.29	.28
$\frac{E_2I_2}{E_1I_1}$	29.4	32.3	32.7	29.2	30.8	28.8	26.7	31.4
K	10.2	11.2	14	13.2	10.3	9.9	9.3	9.8
K'	.313	.299	.267	.275	.312	.318	.328	.319
$\pi^2/(\ell e/r)^2$	.00527	.00649	.0104	.00834	.00500	.00398	.00317	.00291
σ_{cr} (ksi)	31.8	32.0	32.4	32.3	31.6	31.2	30.5	30.7
P_{cr} (K)	383	376	374	408	397	404	418	379

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JOB 438-80 - Charleston Naval Shipyard
SHEET NO 2 OF 3
CALCULATED BY BWL DATE 4-7-82
CHECKED BY DLP DATE 4/26/82
SCALE

PIER DELTA - continued

Jacket Stiffness $\left(\frac{E_2 I_2}{E_1 I_1}\right)$:

$$\frac{E_2}{E_1} I_2 = I_{\substack{effective \\ concrete}} + I_{Y\text{-}Y\text{-}HP\,12\times 53} = \frac{\pi (28'')^4}{64}(.1) + 127 =$$

$$3017 + 127 = 3144 \text{ in.}^4$$

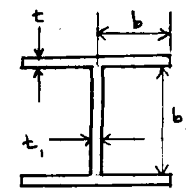
$$\frac{E_2 I_2}{E_1 I_1} = \frac{3144 \text{ in.}^4}{I_r}$$

II. LOCAL BUCKLING
(note: Local P_{cr} has factor of safety incorporated)
Allowable Values:

$$\frac{b}{t} < \frac{3000}{\sqrt{\sigma_Y}} = 16.5$$

$$\frac{b_1}{t_1} < \frac{8000}{\sqrt{\sigma_Y}} = 44.0$$

where
$\sigma_Y = 33$ KSI
t = minimum flange thickness (in.)
t_1 = minimum web thickness (in.)



note: A_{min} = Minimum Remaining Cross-Sectional Area of Column (in.^{2})

PILE	b	t	b/t	b_1	t_1	b_1/t_1	$A_{min.}$	Local σ_{cr} (KSI)	Local P_{cr} (K)
73-H2	6.023"	.310	19.4 *	10.908"	.225	48.5*	9.92	(±) 35.18	349
74-G-3	↓	.310	19.4 *	↓	.295	37.0	10.69	35.18	376
75-D-1		.285	21.1 *		.285	38.3	9.98	29.74	297
70-C2		.325	18.5 *		.295	37.0	11.05	38.67	427
78-C2		.310	19.4 *		.340	32.1	11.18	35.18	393
82-D-3		.325	18.5 *		.335	32.6	11.48	38.67	444
82-C1		.360	16.7 *		.325	33.6	12.22	47.45	580
82-H2	↓	.310	19.43 *	↓	.330	33.0	11.07	35.18	389

* Indicates ratio exceeds allowable value.

Critical Local Buckling Stress for Flanges:

$$\sigma_{cr} = \frac{.416E}{1-\nu^2}\left(\frac{t}{b}\right)^2 = 13.282 \times 10^6 \left(\frac{t}{b}\right)^2 \quad \text{where } \nu = .27,\ E = 29.6 \times 10^6 \text{ psi}$$

Critical Local Buckling Stress for Web:

$$\sigma_{cr} = \frac{3.29E}{1-\nu^2}\left(\frac{t_1}{b_1}\right)^2 = 105.04 \times 10^6 \left(\frac{t_1}{b_1}\right)^2 \quad \text{Where } \nu = .27,\ E = 29.6 \times 10^6 \text{ psi}$$

PIER DELTA – continued

III. COMBINED BUCKLING LOADS

Pile	$P_{cr}^{(K)}$	Factor of Safety	Column $P_{cr}^{(K)}$	Local $P_{cr}^{(K)}$	Allowable Buckling Load
73-H2	383	2.75	139	349	139 K = 69.5 Tons
74-G-3	376	↓	137	376	137 K = 68.5 Tons
75-D-1	374	↓	136	297	136 K = 68.0 Tons
70-C2	408	↓	148	427	148 K = 74.0 Tons
78-C2	397	↓	144	393	144 K = 72.0 Tons
82-D-3	404	↓	147	444	147 K = 73.5 Tons
82-C1	418	↓	152	580	152 K = 76.0 Tons
82-H2	379	↓	138	389	138 K = 69.0 Tons

∴ Local buckling is not controlling for any pile.

IV. PIER LOADING

A.) DEAD LOAD on D and G Piles (in pile Groups of 5 verticals and one batter):

Group Deck Volume ⇒ (14.0'W × 20.0'L × .75'D) +
Volume of 4 Beams ⇒ (1.5'W × 7.0'L × 2.5'D)4 +
Group Pile Cap Volume ⇒ (6.0'W × 9.0'L × 3.0'D) +
Between-Group Pile Cap Volume ⇒ (1.5'W × 5.0'L × 3.0'D) +
Concrete Jacket Volume ⇒ $(\pi(1.17')^2 \times 12.3'L)5$ =
TOTAL VOLUME ⇒ 764.0 cf.

Weight of Concrete ⇒ 150 pcf × 764.0 cf = 114,600 lbs.
DEAD LOAD per Pile Group = 114,600 lbs/280 sf = 409 PSF ≅ 410 PSF

Design Live load of Deck = 600 psf uniform loading. ∴ Total Load = 1010 psf

CONCLUSION: D & G Piles must have a minimum bearing capacity of
280 sf × 1010 psf/5 piles = 56,560 lbs/pile = 28.3 Tons/pile
As seen in Part III, all D & G Piles analyzed can carry the imposed loads.

B.) DEAD LOAD on C and H Piles (in Pile Groups of 2 verticals):

$\underbrace{(7.5'W \times 20.0'L \times .75'D)}_{\text{Deck Volume}} + \underbrace{(6.0'W \times 14.0'L \times 2.5'D)}_{\text{Beam Volume}} + \underbrace{(2.7'W \times 6.0'L \times 2.8'D)}_{\text{Group Pile Cap Volume}} + \underbrace{(1.5'W \times 4.8'L \times 2.8'D)}_{\text{Between-Group Pile Cap Volume}} + \underbrace{(\pi(1.17')^2 \times 12.3'L)2}_{\text{Concrete Jacket Volume}} =$

318.8 cf (TOTAL VOLUME) ; Weight of Concrete = 150 pcf × 318.8 cf = 47,820 lbs.
DEAD LOAD per Pile Group = 47,820 lbs/150 sf = 318.8 psf ≅ 320 psf
Deck Design Live Load = 600 psf uniform loading. ∴ TOTAL LOAD = 600 psf + 320 psf = 920 psf

CONCLUSION: C + H Piles must have a minimum bearing capacity of 150 sf × 920 psf/2 piles = 69,000 lbs/pile = 34.5 Tons/pile. As seen in Part III, all C & H Piles analyzed can carry the imposed loads.

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MEDFIELD, MA 02052

PIER HOTEL - COLUMN ANALYSIS

[Refer to Childs Engineering Report entitled "Analysis of the Remaining Strength of Concrete Jacketed Steel H-Piles", Feb. 1982]

I. PILE LOAD ANALYSIS

Note: Refer to Pier DELTA's Column Analysis for Definition of Terms used below.

Assumption: Steel is A-7 ($F_Y = 33$ KSI)

Note: The columns investigated are in the inelastic buckling range ($\ell_e/r < C_c = 133.1$), so the tangent modulus, E_t, must be used to calculate column P_{cr} & σ_{cr}.

$$\sigma_{cr} = \frac{K\pi^2 E_t}{(\ell/r)^2} = \frac{\pi^2 E_t}{(\ell_e/r)^2} \qquad P_{cr} = (\sigma_{cr})(A_r)$$

Jacket Stiffness:

a.) HP 12 x 53: $\frac{E_2}{E_1} I_2 = I_{\substack{effective \\ concrete}} + I_{Y-Y-HP12\times53} = \left(\frac{\pi(24")^4}{64}\right)(.1) + 127 = 1756 \text{ in}^4$

$\therefore \frac{E_2 I_2}{E_1 I_1} = \frac{1756 \text{ in}^4}{I_r}$

b) HP 12 x 74: $\frac{E_2}{E_1} I_2 = I_{\substack{effective \\ concrete}} + I_{Y-Y-HP12\times74} = \left(\frac{\pi(24")^4}{64}\right)(.1) + 185 = 1814 \text{ in}^4 \therefore \frac{E_2 I_2}{E_1 I_1} = \frac{1814 \text{ in}^4}{I_r}$

PILE	9-K	19-D	45-K	1-K	9-A	59-A	49-B	34-#1	24-A	19-B	
TYPE	HP 12x53	HP 12x53	HP 12x74	HP 12x53	HP 12x53	HP 12x53	HP 12x53	HP 12x53	HP 12x53	HP 12x53	
Web r (in)	.360	.275	.392	.378	.349	.320	.370	.287	.340	.302	
Fl r (in.)	.285	.265	.362	.361	.332	.370	.332	.335	.310	.285	
A_r (in.^{2})	10.76	9.36	13.10	12.78	11.77	12.37	12.00	11.16	11.15	10.13	
I_r (in.^{4})	82.1	76.3	110	104	95.6	107	95.6	96.5	89.3	82.1	
r_r (in.)	2.76	2.86	2.90	2.85	2.85	2.94	2.82	2.94	2.83	2.85	
ℓ (in.)	411	327	471	507	459	387	387	375	399	387	
A/ℓ	.36	.48	.34	.27	.31	.36	.37	.38	.35	.36	
$\frac{E_2 I_2}{E_1 I_1}$	21.4	23.0	16.0	16.9	18.4	16.4	18.4	18.2	19.7	21.4	
K	9.2	13.8	8.5	8.0	8.8	8.6	8.8	8.8	9.0	9.2	
K'	.330	.269	.343	.354	.337	.341	.337	.337	.333	.330	
$\pi^2/(\ell_e/r)^2$	.00409	.0104	.00318	.00249	.00335	.00490	.00461	.00534	.00448	.00492	
σ_{cr} (ksi)	31.35	32.4	30.9	30.3	31.0	31.7	31.55	31.75	31.5	31.7	
P_{cr} (k)	337	303	405	387	365	392	379	354	351	321	

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JOB 438-80 - Charleston Naval Shipyard
SHEET NO 2 OF 3
CALCULATED BY BWL DATE 4-6-82
CHECKED BY DLP DATE 4/26/82
SCALE

PIER HOTEL - continued

II. LOCAL BUCKLING

[Refer to Pier DELTA Column Analysis for Definition of Terms used below]

Pile	b	t	b/t	b_1	t_1	b_1/t_1	$A_{min.}$ (in.^{2})	Local σ_{cr} (KSI)	Local P_{cr} (K)
9-K	6.023"	.245"	24.6 *	10.908"	.345"	31.6	9.67	21.98	213
19-D	"	.240"	25.1 *	"	.215"	50.7 *	8.13	(F) 21.09	171
45-K	6.108"	.300"	20.4 *	10.906"	.320"	34.1	10.82	32.04	347
1-K	6.023"	.330"	18.2 *	10.908"	.335"	32.6	11.60	39.87	462
9-A	"	.220"	27.4 *	"	.295"	37.0	8.52	17.72	151
59-A	"	.365"	16.5 *	"	.280"	39.0	11.85	48.78	578
49-B	"	.325"	18.5 *	"	.320"	34.1	11.32	38.67	438
34-#1	"	.305"	19.8 *	"	.225"	48.5 *	9.80	(F) 34.06	334
24-A	"	.245"	24.6 *	"	.295"	37.0	9.12	21.98	200
19-B	"	.240"	25.1 *	"	.235"	46.4 *	8.35	(F) 21.09	176

* Indicates ratio exceeds allowable value.

Buckling Stress for flanges: $\sigma_{cr} = \frac{.416E}{1-\nu^2}\left(\frac{t}{b}\right)^2 = 13.282 \times 10^6 \left(\frac{t}{b}\right)^2$ where $\nu = .27$, $E = 29.6 \times 10^6$ psi

Buckling Stress for Webs: $\sigma_{cr} = \frac{3.29E}{1-\nu^2}\left(\frac{t_1}{b_1}\right)^2 = 105.04 \times 10^6 \left(\frac{t_1}{b_1}\right)^2$ where $\nu = .27$, $E = 29.6 \times 10^6$ psi

III. COMBINED BUCKLING LOADS

Pile	P_{cr} (K)	Factor of Safety	Column P_{cr} (K)	Local P_{cr} (K)	Allowable Buckling Load
9K	337	2.75	123	213	123 K = 61.5 Tons
19-D	303	↓	110	171	110 K = 55.0 Tons
45-K	405	↓	147	347	147 K = 73.5 Tons
1-K	387	↓	141	462	141 K = 70.5 Tons
9-A	365	↓	133	151	133 K = 66.5 Tons
59-A	392	↓	143	578	143 K = 71.5 Tons
49-B	379	↓	138	438	138 K = 69.0 Tons
34-#1	354	↓	129	334	129 K = 64.5 Tons
24-A	351	↓	128	200	128 K = 64.0 Tons
19-B	321	↓	117	176	117 K = 58.5 Tons

∴ Local Buckling is not controlling.

PIER HOTEL - continued

IV. PIER LOADING

a) DEAD LOAD FOR A & K Piles (not supporting cranes):

Deck Volume + Beam Volume + Pile Cap Volume

$[8.25'w \times 12.0'L \times .83'D] + [2.0'w \times 12.0'L \times 3.5'D] + [1.25'w \times 8.25'L \times 1.75'D] =$

(Total Volume) 184.2 c.f. ; Wt. of Concrete = 150pcf × 184.2 c.f. = 27.6^K

DEAD LOAD = $27.6^K / 99$ sq.ft = 279 psf ≅ 280 psf

Deck Design Live load = 600 psf Uniform loading, so TOTAL LOAD = 600 psf + 280 psf = 880 psf

CONCLUSION:

∴ Piles must have a minimum bearing capacity of 880 psf × 99 s.f. = 87,120 lbs = 43.6 Tons
As seen from Part III, all A & K piles analyzed can carry the imposed loads.

b) DEAD LOAD on B-Piles (and #1, if it were vertical), supporting 40-Ton Crane:

Deck Volume ⇒ $[7.5'w \times 6.0'L \times .83'D]$ +
Beam Volume ⇒ $[6.0'L \times 2.0'w \times 3.5'D]$ +
Pile Cap Volume ⇒ $[7.5'L \times 1.25'w \times 2.0'D]$ =
TOTAL VOLUME ⇒ 98.1 c.f. ; Wt. of Concrete = 98.1 c.f. × 150 pcf = 14.7^K

Maximum Design Wheel load for 40-Ton Crane = 67^K ; TOTAL LOAD = $\frac{14.7^K + 67^K}{45 \text{ s.f.}}$ = 1816 psf

CONCLUSION:

∴ Piles must have a minimum bearing capacity of 1816 psf × 45 s.f. = 81,720 lbs = 40.9 Tons
As seen in Part III, all B Piles (+ #1 Piles) analyzed can carry the imposed loads.

c) DEAD LOAD on D Piles, supporting 50-Ton Crane:

Deck Volume ⇒ $[9.5'w \times 4.0'L \times .83'D]$ +
Beam Volume ⇒ $[2.0'w \times 4.0'L \times 3.5'D]$ +
Pile Cap Volume ⇒ $[1.25'w \times 9.5'L \times 2.0'D]$ =
TOTAL VOLUME ⇒ 83.3 c.f. ; Wt. of Concrete = 150 pcf × 83.3 c.f. = 12.5^K

Maximum Design Wheel load for 50-Ton Crane = 91^K

TOTAL LOAD = $\frac{12.5^K + 91^K}{38 \text{ sf}}$ = 2724 psf.

CONCLUSION:

∴ Piles must have a minimum bearing capacity of 2724 psf × 38 sf = 103.5^K = 51.8 Tons
As seen in Part III, the D pile analyzed can carry the imposed loads, but is approaching the minimum bearing capacity.

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JOB 438-80 - Charleston Naval Shipyard
SHEET NO 1 OF 2
CALCULATED BY BWL DATE 3-16-82
CHECKED BY DLP DATE 4/26/82
SCALE

PIER JULIET - COLUMN ANALYSIS

[Refer to Childs Engineering Report entitled "Analysis of The Remaining Strength of Concrete Jacketed Steel H-Piles", Feb., 1982]

I. PILE LOAD ANALYSIS

Note: Refer to Pier DELTA's Column Analysis for Definition of Terms used below.

Assumptions: Steel is A-7 ($F_y = 33$ ksi)

Note: The columns investigated are in the inelastic buckling range ($l_e/r < C_c = 133.1$), so the tangent modulus, E_t, must be used to calculate column P_{cr} & σ_{cr}.

$$\sigma_{cr} = \frac{\pi^2 E_t}{(l_e/r)^2} \qquad P_{cr} = (\sigma_{cr})(A_r)$$

Jacket Stiffness (see Pier HOTEL's Column Analysis calculation of $\frac{E_2}{E_1} I_2$):

a) HP 12×53: $\frac{E_2 I_2}{E_1 I_1} = \frac{1756 \text{ in}^4}{I_r}$

b) HP 12×74: $\frac{E_2 I_2}{E_1 I_1} = \frac{1814 \text{ in}^4}{I_r}$

PILE	0-K	49-A	39-D	34-A	24-#1	14-H	44-K	44-#2
TYPE	HP 12×74	HP 12×53	HP 12×53	HP 12×53	HP 12×53	HP 12×53	HP 12×53	HP 12×74
Web t_r (in.)	.362	.325	.299	.362	.306	.303	.338	.422
Fl t_r (in)	.439	.322	.315	.354	.255	.298	.349	.607
A_r (in²)	14.67	11.30	10.85	12.48	9.48	10.48	12.10	19.43
I_r (in⁴)	133.4	93.8	91.8	103.1	74.3	86.8	101.7	184.5
r_r (in.)	3.01	2.88	2.91	2.87	2.80	2.88	2.90	3.08
l (in.)	390	399	351	372	351	315	293	291
A/l	.35	.34	.45	.42	.48	.54	.38	.58
$\frac{E_2 I_2}{E_1 I_1}$	13.60	18.72	19.13	17.03	23.64	20.23	17.27	9.83
K	8.12	8.9	11.5	10.5	14.0	13.2	9.8	9.8
K'	.351	.335	.295	.309	.267	.275	.319	.319
$\pi^2/(l_e/r)^2$	.00480	.00458	.00779	.00615	.00881	.01091	.00528	.01096
σ_{cr} (ksi)	31.6	31.4	32.1	31.9	32.3	32.4	31.8	32.4
P_{cr} (K)	464	355	348	398	306	340	385	630

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JOB 438-80- Charleston Naval Shipyard
SHEET NO 2 OF 2
CALCULATED BY BWL DATE 3-16-82
CHECKED BY DLP DATE 4/26/82
SCALE

PIER JULIET - continued

II. LOCAL BUCKLING
[Refer to Pier DELTA's Column Analysis for Definition of Terms used below]

Pile	b	t	b/t	b_1	t_1	b_1/t_1	A_{min} (in²)	Local σ_{cr} (KSI)	Local P_{cr} (K)
0-K	6.108"	.375"	16.3	10.906"	.340"	32.1	12.87	—	—
49-A	6.023"	.200"	30.1*	10.908"	.265"	41.2	7.71	14.64	113
39-D	"	.230"	26.2*	"	.270"	40.4	8.49	19.37	164
34-A	"	.245"	24.5*	"	.335"	32.6	9.56	21.98	210
24-#1	"	.225"	26.8*	"	.230"	47.4*	7.93	(t_1) 18.54	147
14-H	"	.285"	21.1*	"	.285"	38.3	9.98	29.74	297
44-K	"	.305"	19.7*	"	.240"	45.4*	9.96	(t_1) 34.06	339
44-#2	"	.607"	10.1	"	.415"	26.3	19.36	—	—

* Indicates ratio exceeds allowable value (see Pier DELTA's Column Analysis for Local σ_{cr} equations).

III. COMBINED BUCKLING LOADS

Pile	P_{cr} (K)	Factor of Safety	Column P_{cr} (K)	Local P_{cr}	Allowable Buckling Load
0-K	464	2.75	169	—	169K = 84.5 Tons
49-A	355	↓	129	113	113K = 56.5 Tons
39-D	348	↓	126	164	126K = 63.0 Tons
34-A	398	↓	145	210	145K = 72.5 Tons
24-#1	306	↓	111	147	111K = 55.5 Tons
14-H	340	↓	124	297	124K = 62.0 Tons
44-K	385	↓	140	339	140K = 70.0 Tons
44-#2	630	↓	229	—	229K = 114.5 Tons

∴ Local buckling is controlling only for Pile 49-A.

IV. PIER LOADING
[Refer to Pier HOTEL's Column Analysis for calculations of Dead and Total Loads]
a) Minimum bearing capacity for A & K piles (not supporting cranes) is 43.6 Tons. As seen in Part III, all A & K piles analyzed can carry the imposed loads.
b) Minimum bearing capacity for H piles (and #1 + #2 piles, if they were vertical) is 40.9 Tons. As seen in Part III, the H, #1 & #2 piles analyzed can carry the imposed loads.
c) Minimum bearing capacity for D Piles, supporting the 50-Ton Crane, is 51.8 Tons. As seen from Part III, the D pile analyzed can carry the imposed load. However, corrosion has reduced some piles to close to this minimum, so some D piles may be close.

JOB 438-80B CHARLESTON NAVY BASE, S(

CHILDS ENGINEERING CORPORATION
Box 333
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SHEET NO 1 OF 13
CALCULATED BY ______ DATE ______
CHECKED BY ______ DATE ______
SCALE ______

JACKETED H-PILE

STEEL THICKNESS MEASUREMENTS

LOCATION Naval Shipyard PIER Delta

BENT 73 **PILE** H2
PILE TYPE HP12×53

ORIGINAL THICKNESS: .436" WEB
ORIGINAL THICKNESS: .436" FLANGE

El. -3.0'

Elevation	Web	Flange
-3.5'	.295	.380
-4.0'	.395	.315
-5.0'	.240	N/A
-10.0'	.320	.310
-15.0'	.290	.395
El. -20.0'	.225	O.T.

BENT 74 **PILE** G-3
PILE TYPE HP12×53

ORIGINAL THICKNESS: .436" WEB
ORIGINAL THICKNESS: .436" FLANGE

El. -3.0'

Elevation	Web	Flange
-3.5'	.320	.300
-4.0'	.295	.310
-5.0'	.390	.340
El. -17.0'	.355	.385

Note: O.T. = Original Thickness

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JOB 438-80B CHARLESTON NAVY BASE, SC
SHEET NO. 2 OF 13
CALCULATED BY ______ DATE ______
CHECKED BY ______ DATE ______
SCALE ______

JACKETED H-PILE

STEEL THICKNESS MEASUREMENTS

LOCATION NAVAL SHIPYARD PIER DELTA

BENT 75 PILE D-1
PILE TYPE HP 12×53

ORIGINAL THICKNESS: .436" WEB
ORIGINAL THICKNESS: .436" FLANGE

El.	WEB	FLANGE
-3.0'		
-3.5'	.295	.320
-4.0'	.285	.390
-5.0'	.325	.285
-13.5	.405	.325

BENT 70 PILE C2
PILE TYPE HP 12×53

ORIGINAL THICKNESS: .436" WEB
ORIGINAL THICKNESS: .436" FLANGE

El.	WEB	FLANGE
-3.0'		
-3.5'	.410	.410
-4.0'	.370	.395
-5.0'	.295	.325
-16.0'	.310	.345

JOB 438-80B CHARLESTON NAVY BASE, SC

CHILDS ENGINEERING CORPORATION
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SHEET NO. 3 OF 13
CALCULATED BY ______ DATE ______
CHECKED BY ______ DATE ______
SCALE ______

JACKETED H-PILE

STEEL THICKNESS MEASUREMENTS

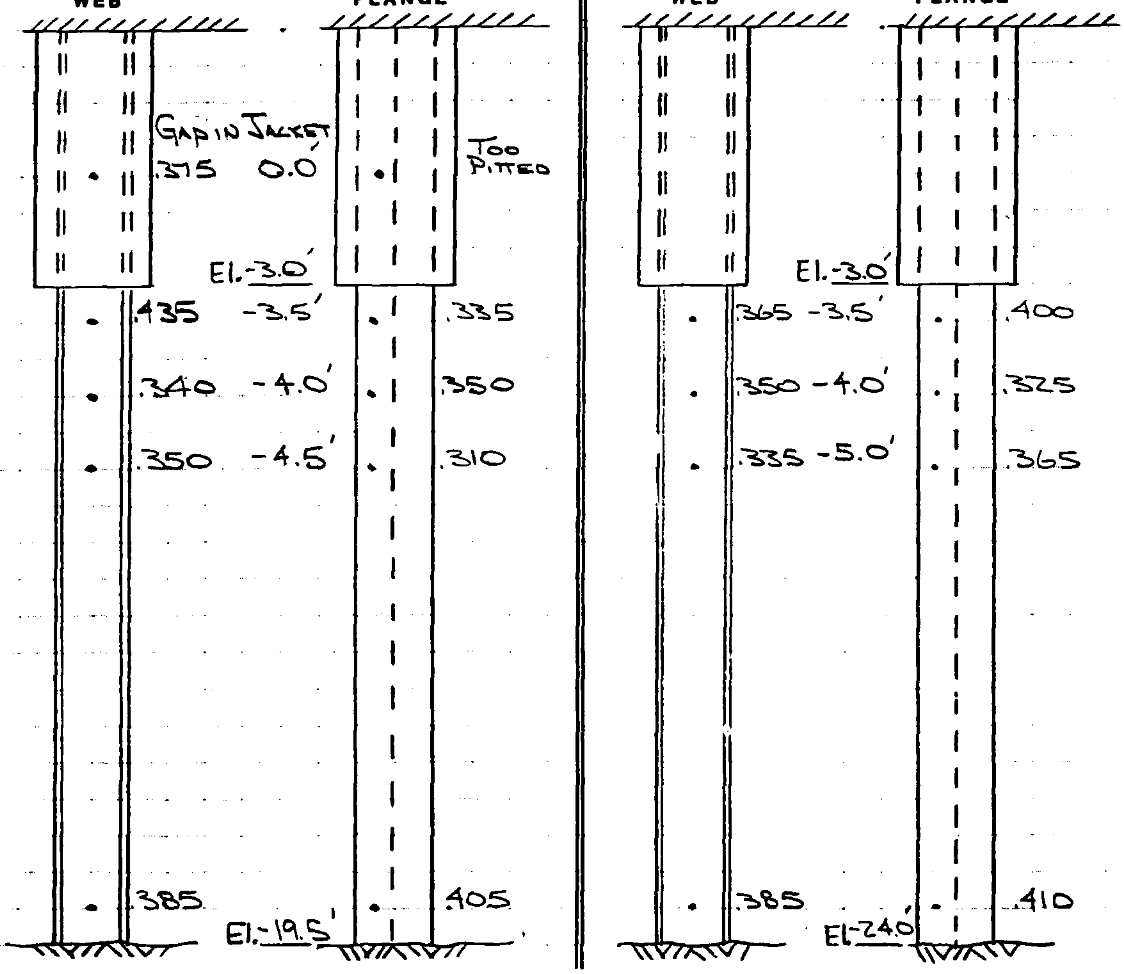
LOCATION NAVAL SHIPYARD PIER DELTA

BENT 78 PILE C2
PILE TYPE HP12x53

ORIGINAL THICKNESS: .436" WEB
ORIGINAL THICKNESS: .436" FLANGE

BENT 82 PILE D-3
PILE TYPE HP12x53

ORIGINAL THICKNESS: .436" WEB
ORIGINAL THICKNESS: .436" FLANGE



JOB 438-80B CHARLESTON NAVY BASE, SC

CHILDS ENGINEERING CORPORATION
Box 333
MEDFIELD, MA 02052

SHEET NO 4 OF 13

CALCULATED BY ________ DATE ________

CHECKED BY ________ DATE ________

SCALE ________

JACKETED H-PILE

STEEL THICKNESS MEASUREMENTS

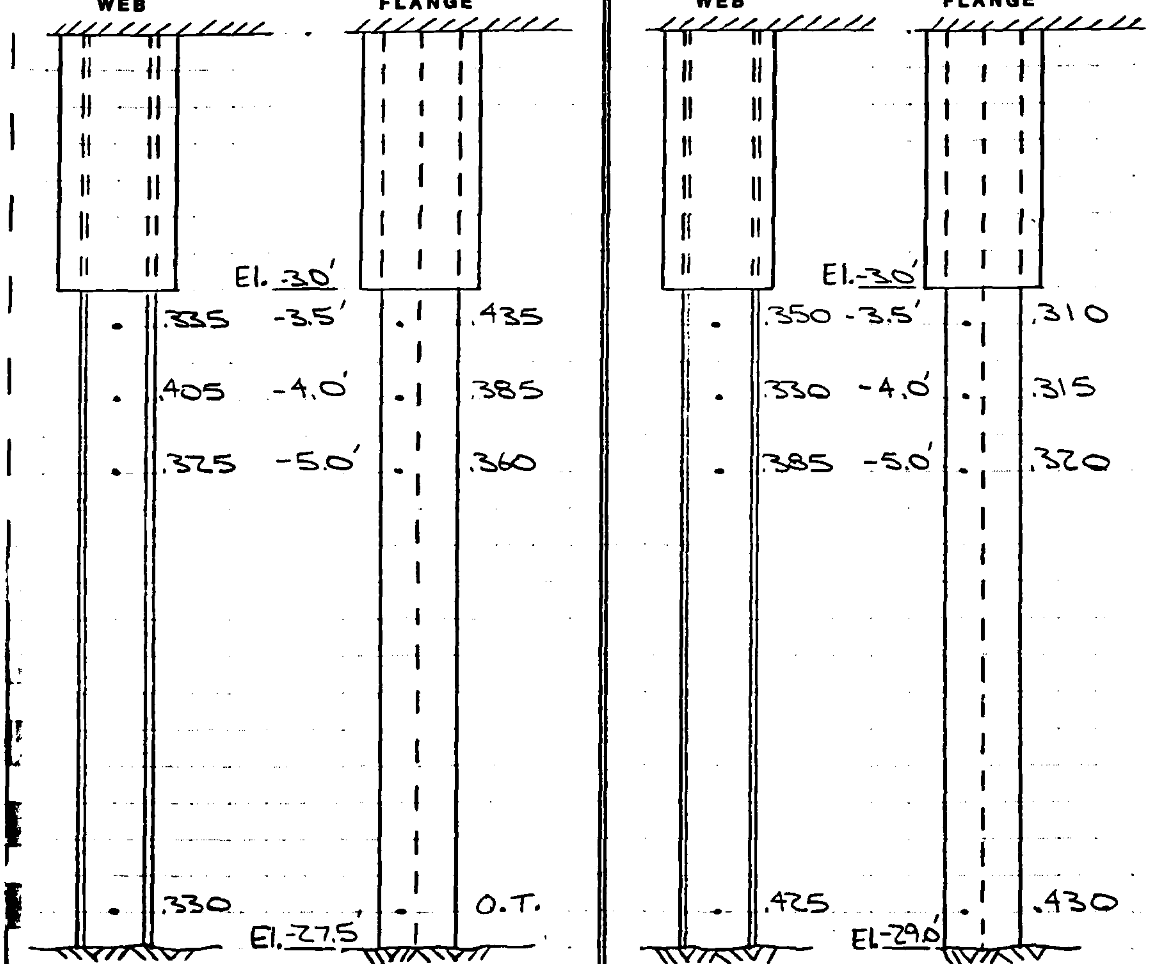
LOCATION NAVAL SHIPYARD PIER DELTA

BENT 82 PILE C1
PILE TYPE HP 12×53

ORIGINAL THICKNESS: .436" WEB
ORIGINAL THICKNESS: .436" FLANGE

BENT 82 PILE H2
PILE TYPE HP 12×53

ORIGINAL THICKNESS: .436" WEB
ORIGINAL THICKNESS: .436" FLANGE



Note: O.T. = Original Thickness

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JOB 438-80B CHARLESTON NAVY BASE, SC
SHEET NO 5 OF 13
CALCULATED BY ______ DATE ______
CHECKED BY ______ DATE ______
SCALE ______

JACKETED H-PILE

STEEL THICKNESS MEASUREMENTS

LOCATION NAVAL SHIPYARD PIER "H"

BENT 9 PILE K
PILE TYPE HP12x53

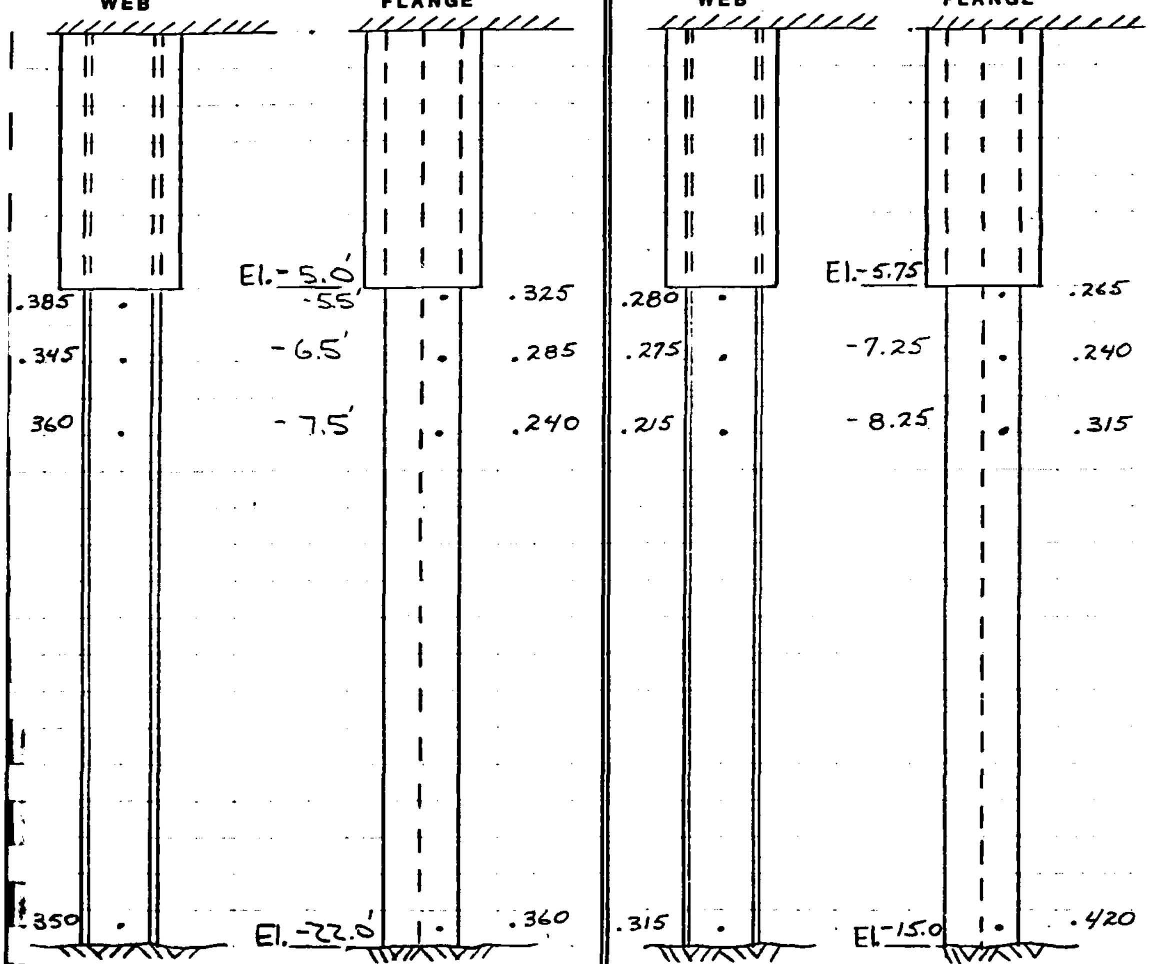
ORIGINAL THICKNESS: .436" WEB

ORIGINAL THICKNESS: .436" FLANGE

BENT 19 PILE D
PILE TYPE HP12x53

ORIGINAL THICKNESS: .436" WEB

ORIGINAL THICKNESS: .436" FLANGE



FORM 204-1 Available from NEBS Inc. Groton Mass 01450

AD-A167 548 UNDERWATER FACILITIES INSPECTIONS AND ASSESSMENTS AT NAVAL SHIPYARD CHARLESTON SOUTH CAROLINA(U) CHILDS&FIELD ENGINEERING CORP MEDFIELD MA MAY 81-FPO-1-80 (11)002 2/2

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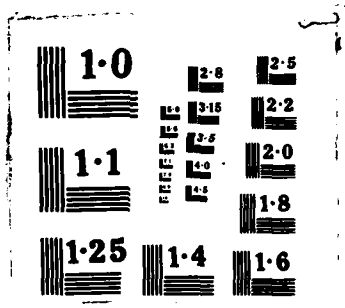
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JOB 438-80B CHARLESTON NAVY BASE, S(

CHILDS ENGINEERING CORPORATION
Box 333
MEDFIELD, MA 02052

SHEET NO 6 OF 13

CALCULATED BY ____ DATE ____

CHECKED BY ____ DATE ____

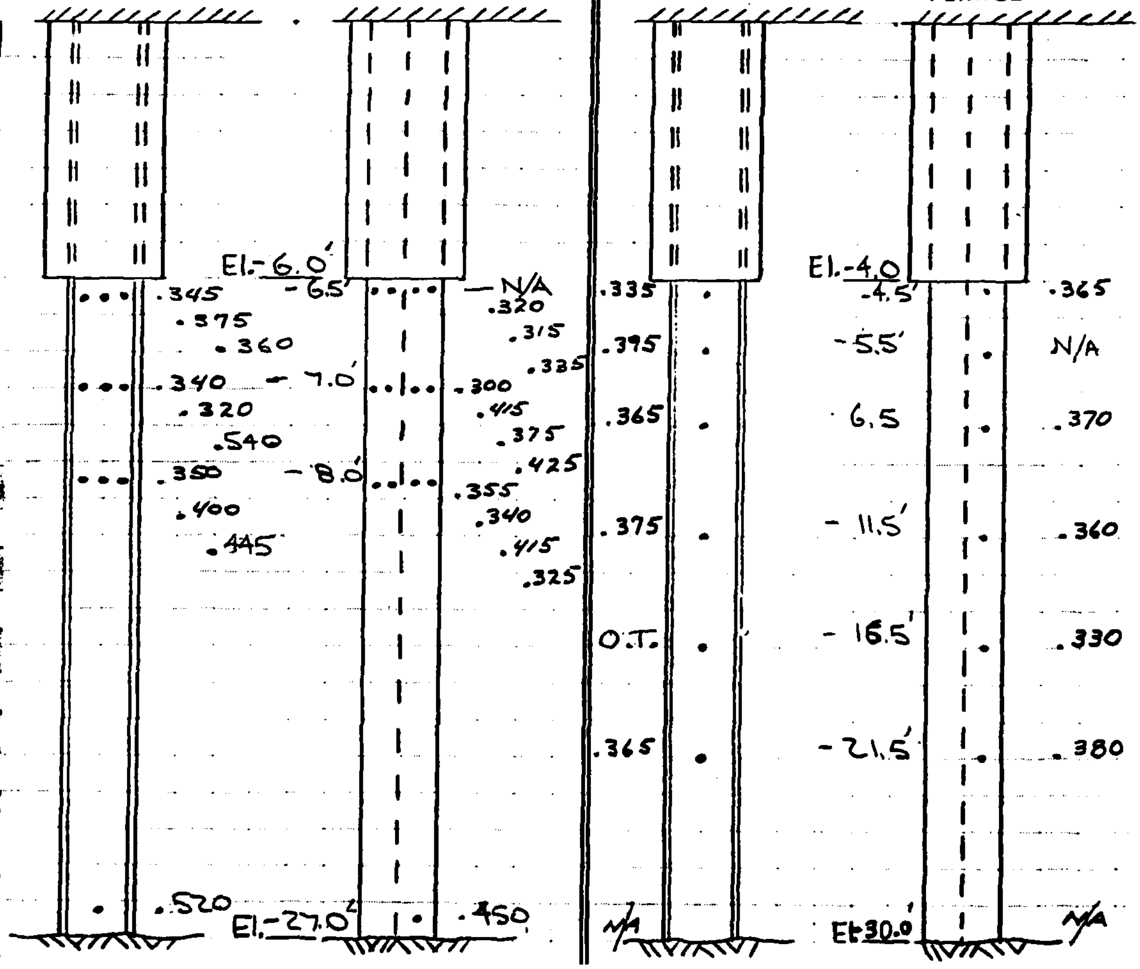
SCALE ____

JACKETED H-PILE

STEEL THICKNESS MEASUREMENTS

LOCATION NAVAL SHIPYARD PIER "H"

BENT 45 PILE K	BENT 1 PILE K
PILE TYPE HP12×74	PILE TYPE HP12×53
ORIGINAL THICKNESS: .607" WEB / ORIGINAL THICKNESS: .607" FLANGE	ORIGINAL THICKNESS: .436" WEB / ORIGINAL THICKNESS: .436" FLANGE



Note: O.T. = Original Thickness

JOB 438-80B CHARLESTON NAVY BASE, SC

CHILDS ENGINEERING CORPORATION
Box 333
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SHEET NO 7 OF 13

CALCULATED BY ________ DATE ________

CHECKED BY ________ DATE ________

SCALE ________

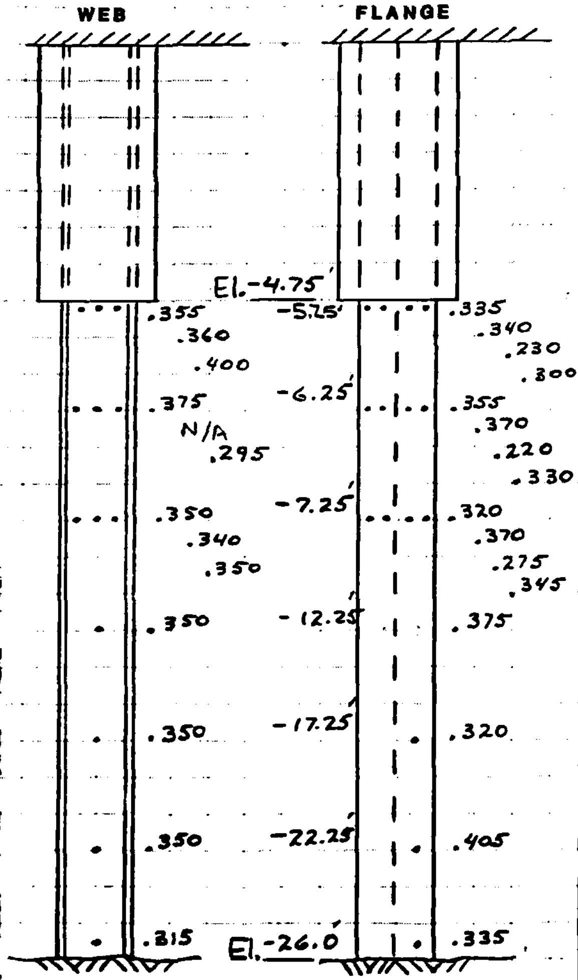
JACKETED H-PILE

STEEL THICKNESS MEASUREMENTS

LOCATION Naval Shipyard PIER "H"

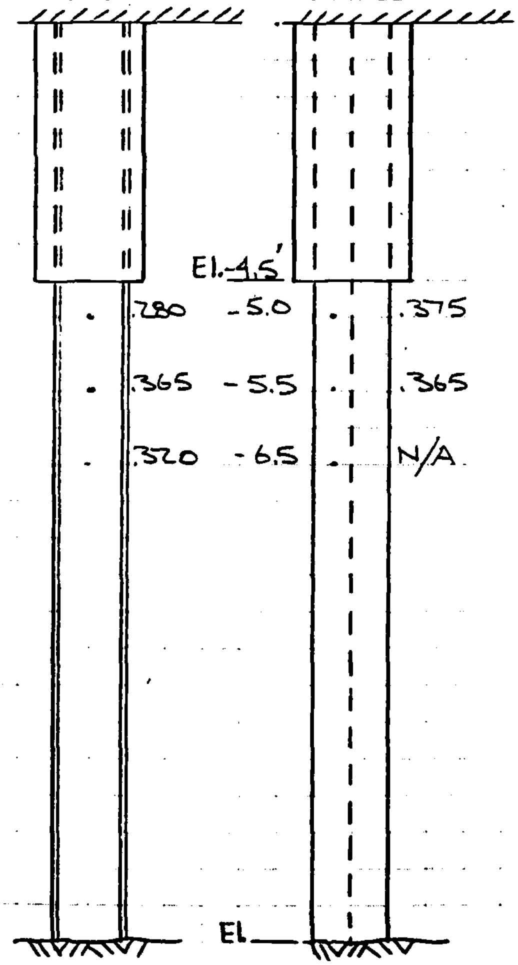
BENT 9 PILE A
PILE TYPE HP12×53

ORIGINAL THICKNESS: .436" WEB
ORIGINAL THICKNESS: .436" FLANGE



BENT 59 PILE A
PILE TYPE HP12×53

ORIGINAL THICKNESS: .436" WEB
ORIGINAL THICKNESS: .436" FLANGE



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SHEET NO 8 OF 13
CALCULATED BY ______ DATE ______
CHECKED BY ______ DATE ______
SCALE ______

JACKETED H-PILE

STEEL THICKNESS MEASUREMENTS

LOCATION NAVAL SHIPYARD PIER H

BENT 49 PILE B
PILE TYPE HP12×53

ORIGINAL THICKNESS: .436" WEB
ORIGINAL THICKNESS: .436" FLANGE

Web	Elevation	Flange
	El. -4.75	
.320	-5.25'	.330
.385	-6.25'	.335
.380	-7.25'	.325
.360	El. -20.0'	.430

BENT 34 PILE #1
PILE TYPE HP12×53

ORIGINAL THICKNESS: .436" WEB
ORIGINAL THICKNESS: .436" FLANGE

Web	Elevation	Flange
	El. -4.75	
.300	-5.25'	N/A
.225	-6.25'	.325
.275	-7.25'	.375
.315	El. -19.0'	.305

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JOB 438-80B CHARLESTON NAVY BASE, S(

SHEET NO 9 OF 13

CALCULATED BY ______ DATE ______

CHECKED BY ______ DATE ______

SCALE ______

)ACKETED H-PILE

STEEL THICKNESS MEASUREMENTS

LOCATION NAVAL SHIPYARD PIER H

BENT 24 PILE A
PILE TYPE HP12×53

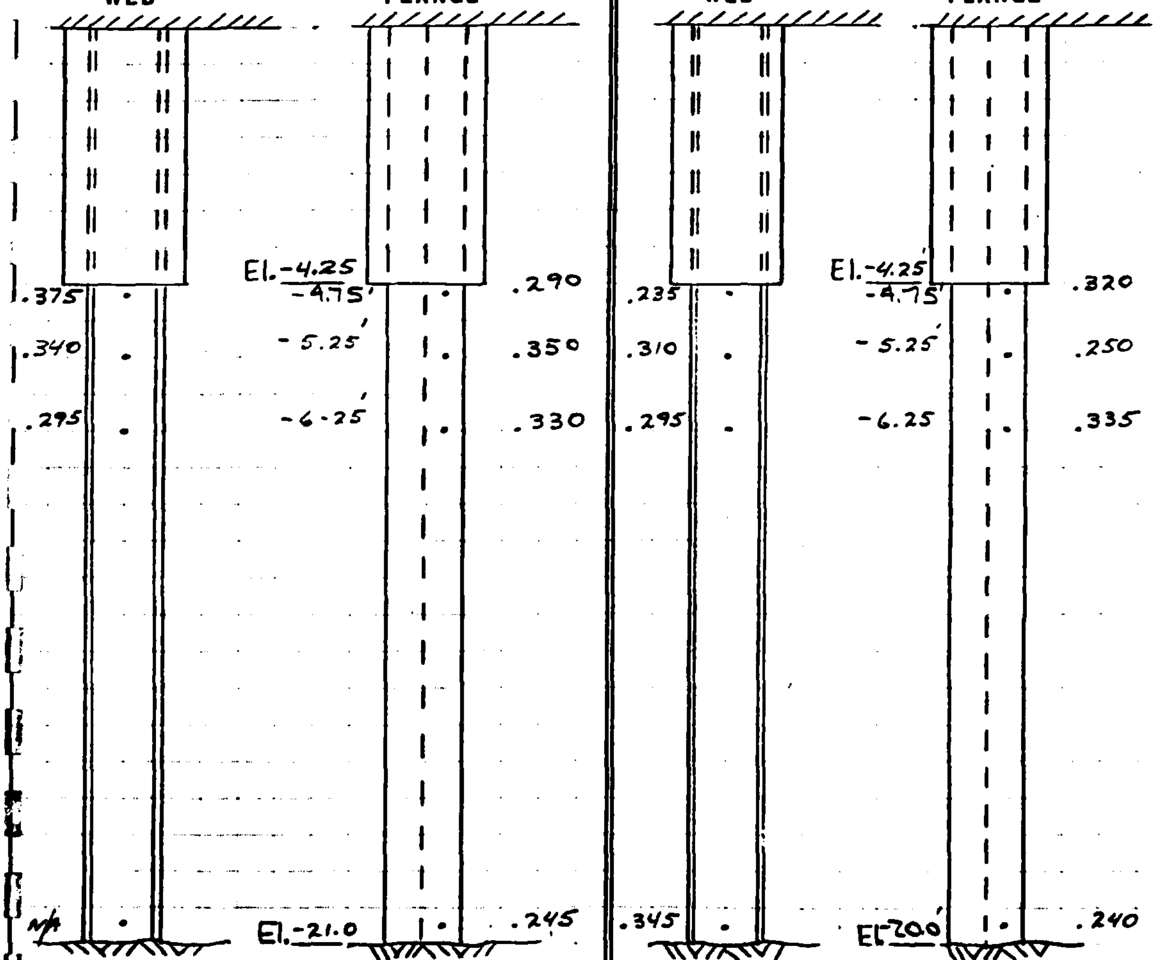
ORIGINAL THICKNESS: .436" WEB

ORIGINAL THICKNESS: .436" FLANGE

BENT 19 PILE B
PILE TYPE HP12-53

ORIGINAL THICKNESS: .436" WEB

ORIGINAL THICKNESS: .436" FLANGE



CHILDS ENGINEERING CORPORATION
Box 333
MEDFIELD, MA 02052

JOB 438-80B CHARLESTON NAVY BASE, S

SHEET NO 10 OF 13

CALCULATED BY ______ DATE ______

CHECKED BY ______ DATE ______

SCALE ______

JACKETED H-PILE

STEEL THICKNESS MEASUREMENTS

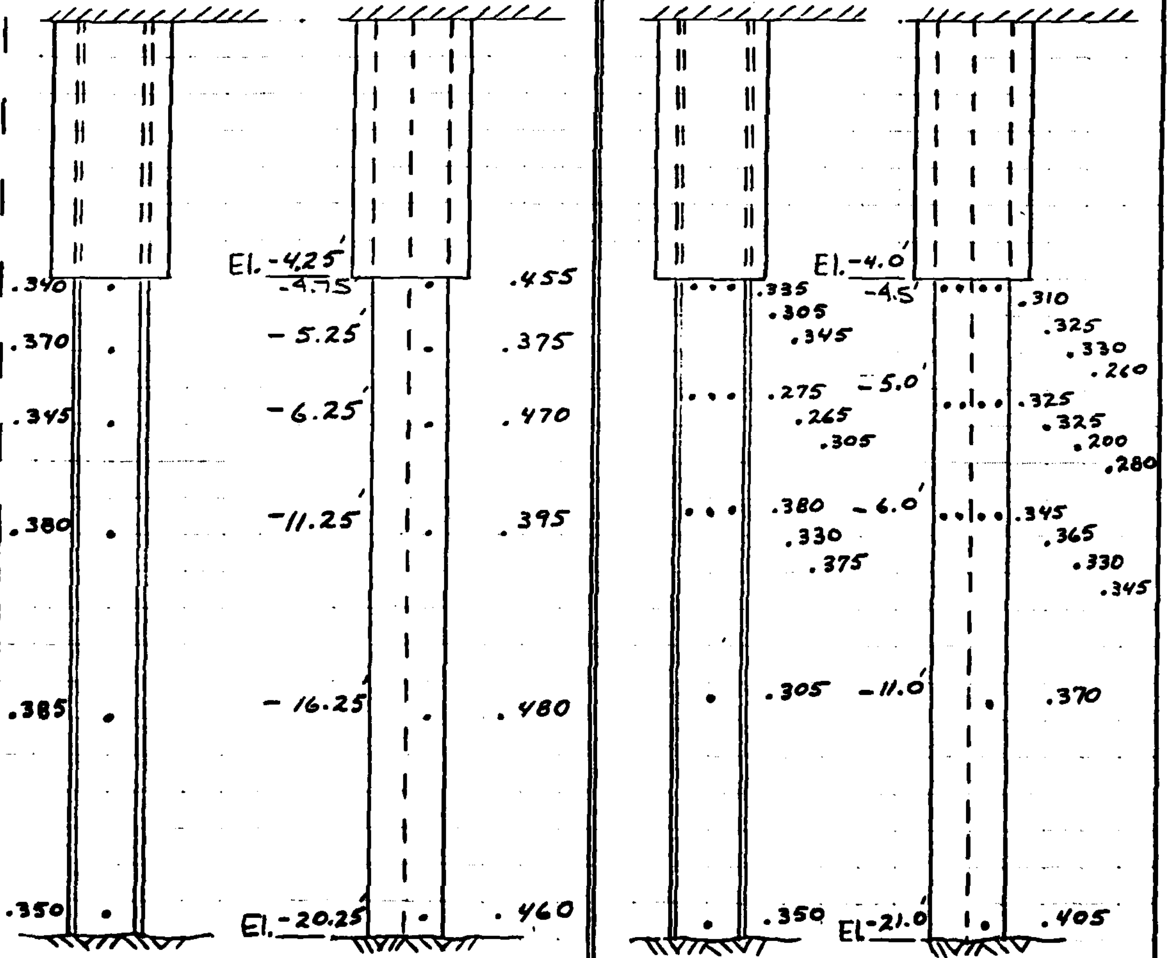
LOCATION NAVAL SHIPYARD PIER "J"

BENT O PILE K
PILE TYPE HP12×74

ORIGINAL THICKNESS: .607" WEB
ORIGINAL THICKNESS: .607" FLANGE

BENT 49 PILE A
PILE TYPE HP12×53

ORIGINAL THICKNESS: .436" WEB
ORIGINAL THICKNESS: .436" FLANGE



Web	Elevation	Flange
	El. -4.25'	
.340	-4.75	.455
.370	-5.25'	.375
.345	-6.25'	.470
.380	-11.25'	.395
.385	-16.25'	.480
.350	El. -20.25'	.460

Web	Elevation	Flange
	El. -4.0'	
.335 .305 .345	-4.5'	.310 .325 .330 .260
.275 .265 .305	-5.0'	.325 .325 .200 .280
.380 .330 .375	-6.0'	.345 .365 .330 .345
.305	-11.0'	.370
.350	El. -21.0'	.405

JOB 438-80B CHARLESTON NAVY BASE, S

CHILDS ENGINEERING CORPORATION
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MEDFIELD, MA 02052

SHEET NO. 11 OF 13

CALCULATED BY ______ DATE ______

CHECKED BY ______ DATE ______

SCALE ______

JACKETED H-PILE

STEEL THICKNESS MEASUREMENTS

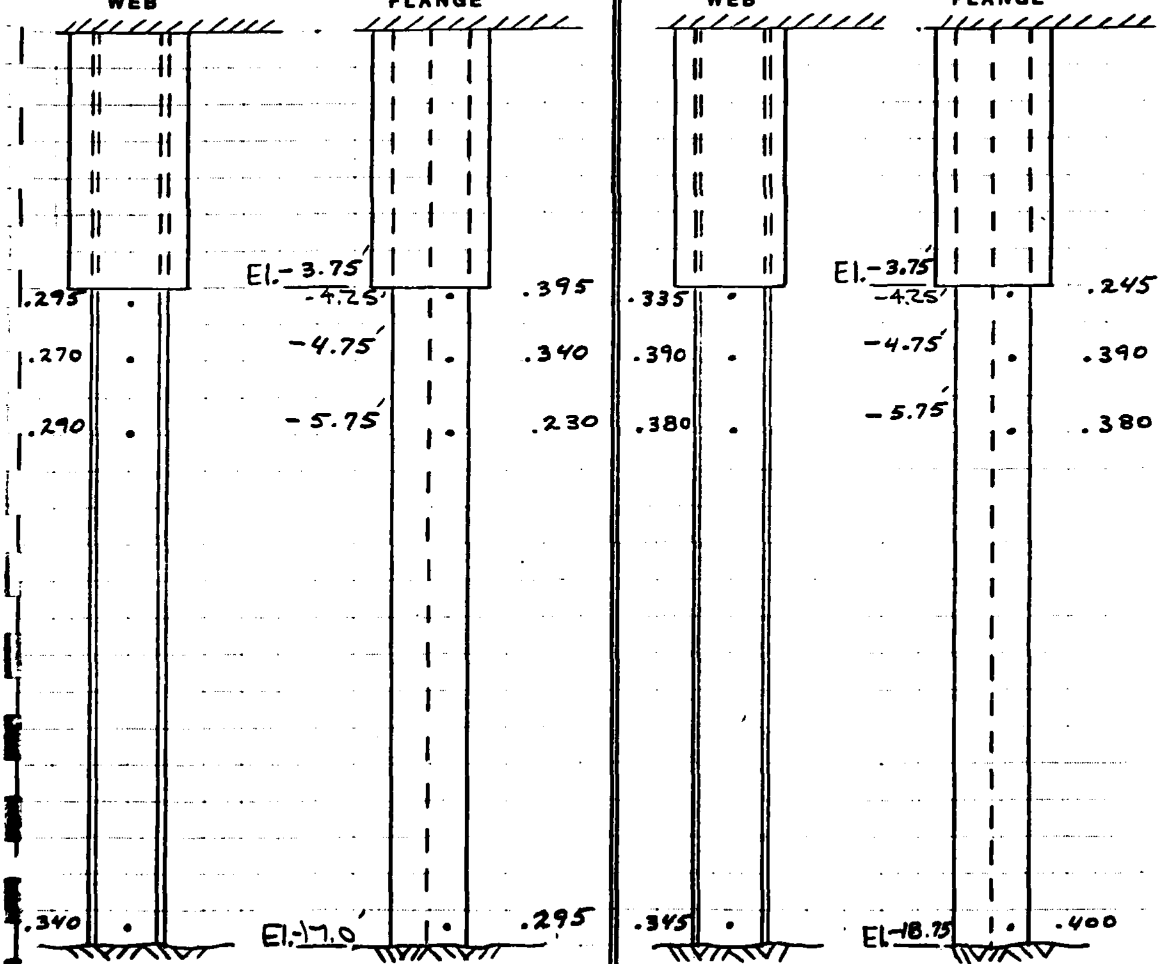
LOCATION NAVAL SHIPYARD PIER "J"

BENT 39 PILE D
PILE TYPE HP12x53

ORIGINAL THICKNESS: .436" (WEB)
ORIGINAL THICKNESS: .436" (FLANGE)

BENT 34 PILE A
PILE TYPE HP12x53

ORIGINAL THICKNESS: .436" (WEB)
ORIGINAL THICKNESS: .436" (FLANGE)



JOB 438-80B CHARLESTON NAVY BASE, S

CHILDS ENGINEERING CORPORATION
Box 333
MEDFIELD, MA 02052

SHEET NO 12 OF 13

CALCULATED BY ______ DATE ______

CHECKED BY ______ DATE ______

SCALE ______

JACKETED H-PILE

STEEL THICKNESS MEASUREMENTS

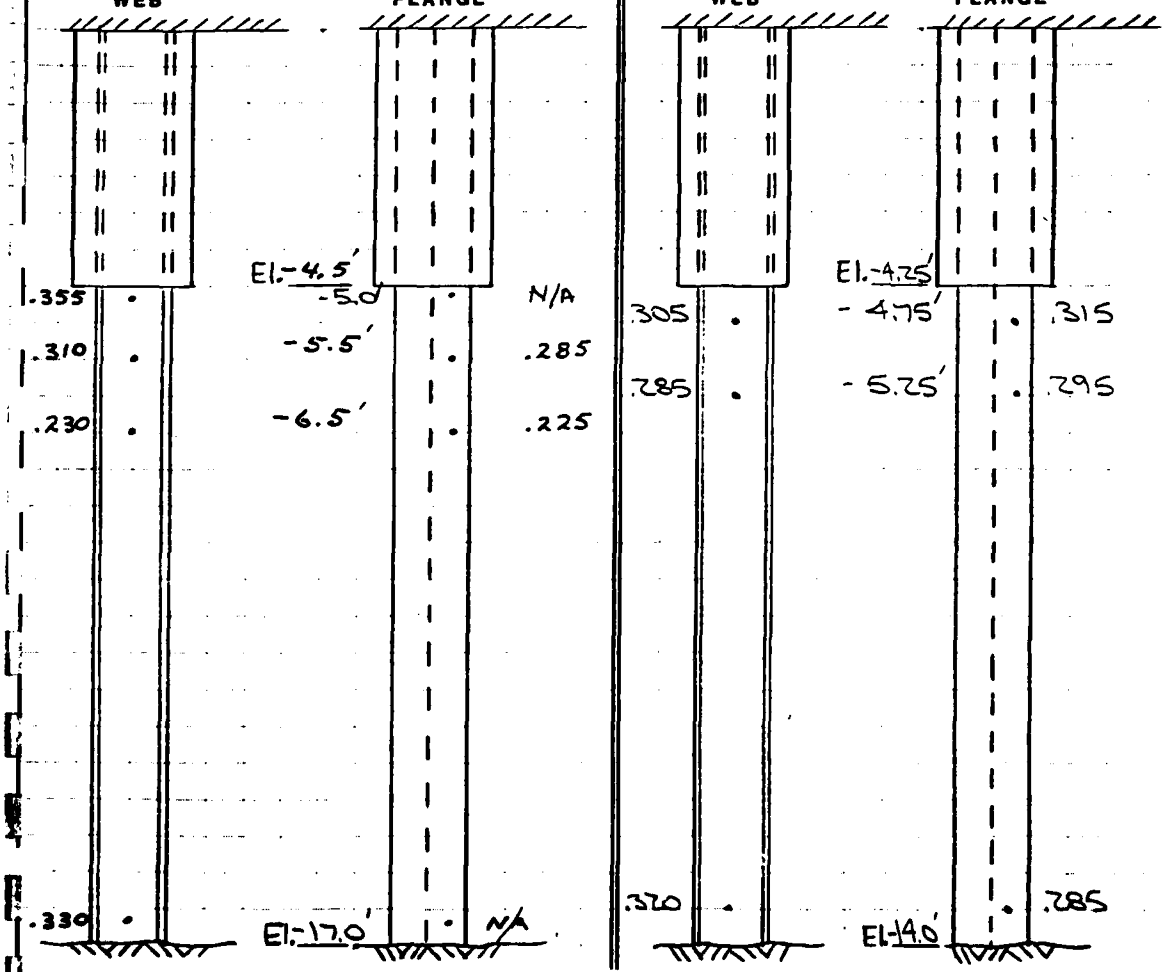
LOCATION NAVAL SHIPYARD PIER "J"

BENT 24 PILE #1
PILE TYPE HP12x53

ORIGINAL THICKNESS: .436" WEB
ORIGINAL THICKNESS: .436" FLANGE

BENT 14 PILE H
PILE TYPE HP12x53

ORIGINAL THICKNESS: .436" WEB
ORIGINAL THICKNESS: .436" FLANGE



FORM 204-1 Available from NEBS Inc. Groton, Mass 01450

JOB 438-80B CHARLESTON NAVY BASE, SC

CHILDS ENGINEERING CORPORATION
Box 333
MEDFIELD, MA 02052

SHEET NO 13 OF 13
CALCULATED BY ____ DATE ____
CHECKED BY ____ DATE ____
SCALE ____

JACKETED H-PILE

STEEL THICKNESS MEASUREMENTS

LOCATION NAVAL SHIPYARD PIER "J"

BENT 44 PILE K
PILE TYPE HP12x53

ORIGINAL THICKNESS: .436" WEB
ORIGINAL THICKNESS: .436" FLANGE

El. -3.25

Web	Elevation	Flange
O.T.	-3.5'	O.T.
.240	-4.25'	.305
.240	-5.25'	.305
O.T.	El. -20.5	.350

BENT 44 PILE #2
PILE TYPE HP12x74

ORIGINAL THICKNESS: .607" WEB
ORIGINAL THICKNESS: .607" FLANGE

El. -4.00

Web	Elevation	Flange
.430	-4.5'	O.T.
.415	-5.00'	N/A
N/A	El. -12.0	N/A

NOTE: O.T. = Original Thickness

A-25

FORM 204-1 Available from NEBS Inc., Groton, Mass 01450

END

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